SEDAR 46 Stock Assessment Review Workshop:

Part 2 DLMtool Results

Sustainable Fisheries Division
Southeast Fisheries Science Center,
Miami, FL

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Outline

SEDAR 46 Results for Assessment method 1:DLMtool

Results to be presented for each species-island unit:

1. Management Strategy Evaluation (MSE)
2. Real world application of the DLMtool
3. Interpretation of results
4. Conclusions

Overall summary

Results

Photos from NOAA Photo Library (http://www.photolib.noaa.gov/).

Application of the DLMtool to six species-island units

PR hogfish dive fishery

STT queen triggerfish trap fishery

STX spiny lobster dive fishery

PR yellowtail snapper handline fishery

STT spiny lobster trap fishery

STX stoplight parrotfish dive fishery

Results

- Species: hogfish
- Island: Puerto Rico
- Gear: diving

Photo from NOAA Photo Library (http://www.photolib.noaa.gov/)

Content:

- MSE
  - Operating model
  - Convergence
  - Tradeoffs & performance
- Catch calculations
- Catch sensitivities
- Guidance

Puerto Rico hogfish: Operating model (OM)

Base OM:

- Stock (15% variability)
- Fleet (Asymptotic)
- Observation (precise, unbiased)

Alternative OMs:

- Stock (5% variability)
- Fleet (Asymptotic)
- Observation (imprecise, biased)

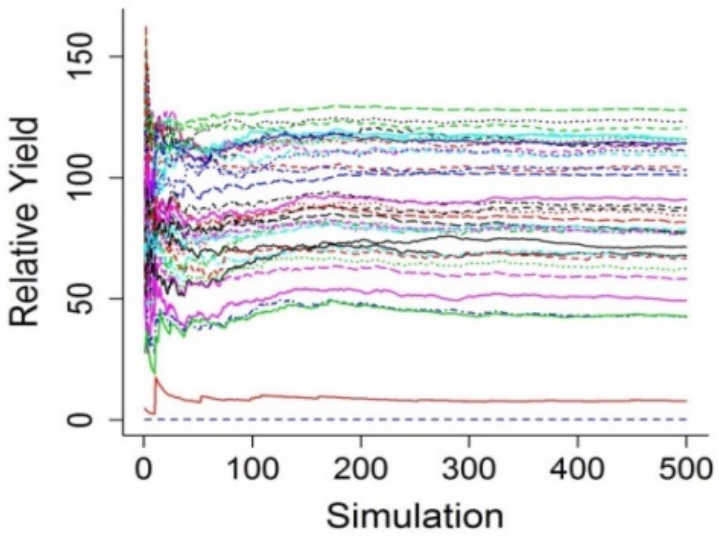
Puerto Rico hogfish: MSE performance results

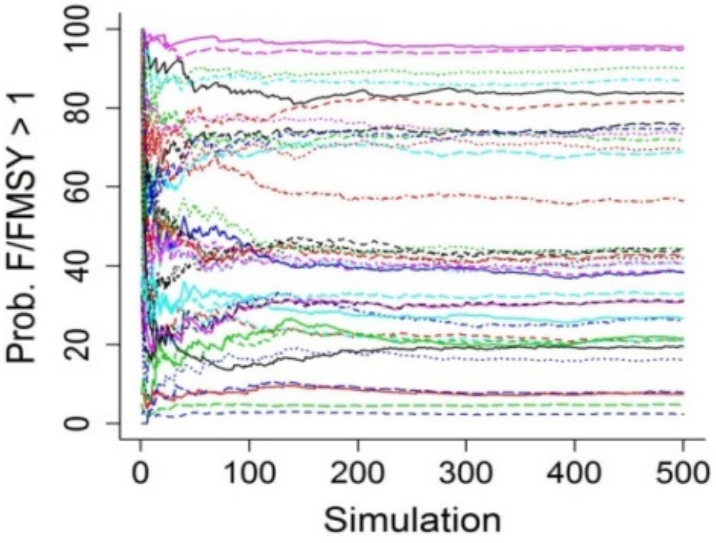
- Model convergence
- Tradeoff plots allow comparison of performance of feasible management procedures (MPs) between base and alternative OMs
  - Feasibility defined by data sufficiency
  - Sensitivity to assumptions made within OM components (stock, observation model inputs)
    - Life history
    - Bias and quality of data inputs

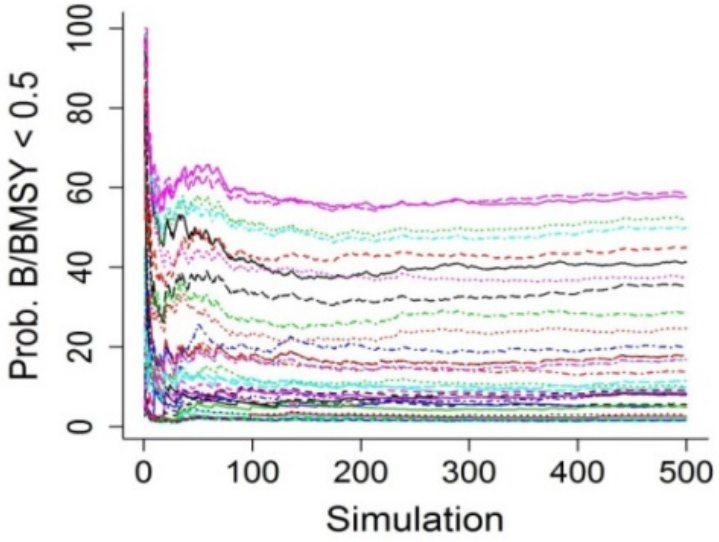
Puerto Rico hogfish: Model convergence

Assumes:

- Base stock, fleet, and subclass OM scenarios
- n=500 sims, 250 reps







All MPs converged at threshold = 1%

Most MPs reached convergence by ~ 300 simulations

Puerto Rico hogfish: Tradeoffs in performance by MP

Assumes:

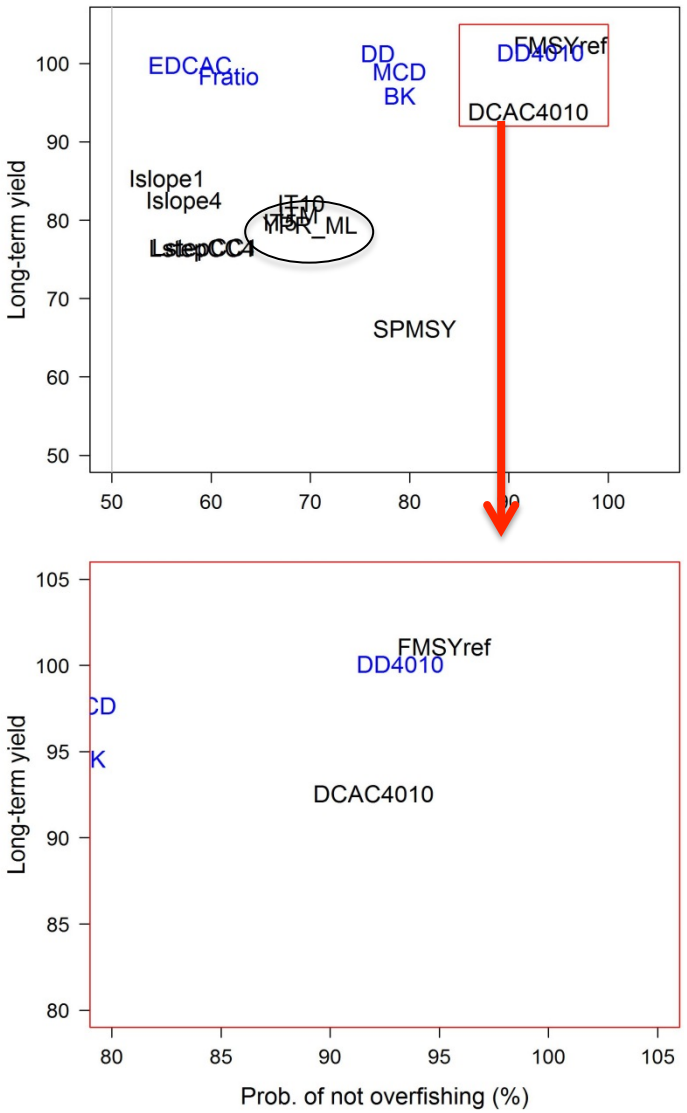
Base stock, fleet, and subclass scenarios

Long-term yield:

- The fraction of simulations achieving over 50% FMSY yield over the final 10 years of the projection

FMSYref:

- Assumes perfect information



YPR_ML = mean length estimator, yield per recruit

- Presented later by Quang Huynh

Puerto Rico hogfish: Tradeoffs in performance by MP

Assumes:

Base stock, fleet, and subclass scenarios

Long-term yield:

- The fraction of simulations achieving over 50% FMSY yield over the final 10 years of the projection

FMSYref:

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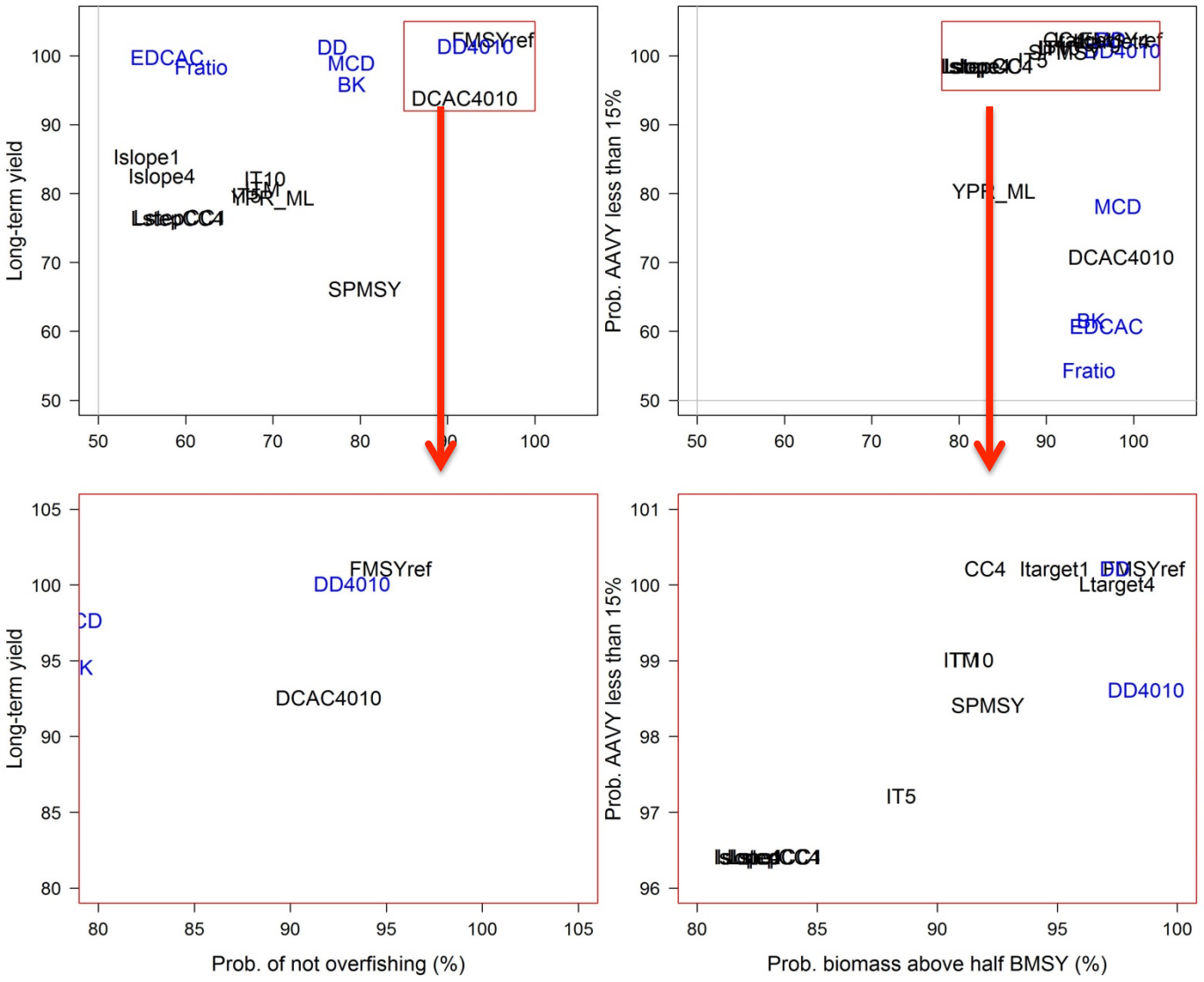


Puerto Rico hogfish: MSE performance

	Base Stock					Alt Stock			
	15% LH, Asymptotic selex					5% LH, Asymptotic selex			
MP	PNOF	B50	LTY	AAVY	MP	PNOF	B50	LTY	AAVY
Reference MP									
FMSYref	95.2	98.6	100	100	FMSYref	96	96.3	100	100
MPs producing 6 highest long-term yields that meet AP criteria									
DD4010	93.2	98.7	99	98.4	DD4010	98	96.9	99.8	93
DD	76.8	97.4	98.9	100	DD	88.8	95.6	99.4	99.8
EDCAC	57.9	96.9	97.4	58.4	EDCAC	67.4	95.5	97.8	62
MCD	79	98.2	96.6	75.8	MCD	85.7	96	96.9	77.4
Fratio	61.8	94.9	96	52	Fratio	60.9	91	96.4	53.2
BK	79	95.1	93.5	59.2	YPR	54.6	86.4	95.5	50.4
Other MPs that meet AP criteria									
DCAC4010	92	98.6	91.5	68.4	BK	76.2	93	93.9	60.6
Islope1	55.6	82.2	83	96.2	DCAC4010	96.1	96.8	88.9	68
Islope4	57.3	82.1	80.2	96.2	Islope1	53.4	78.7	84.4	96.6
IT10	69.1	91.5	79.8	98.8	Islope4	55.6	78.8	78.8	96.4
ITM	68.8	91	78.3	98.8	LstepCC4	57.6	79.8	68.6	97.6
IT5	67	88.5	77.4	97	LstepCC1	57.7	79.5	68.5	97.8
LstepCC1	59.4	83.3	74.2	96.2	SPMSY	67.8	87.2	68.4	98.2
LstepCC4	59.1	83.2	74.1	96.2	IT10	75.3	88.7	62.1	99.2
SPMSY	80.5	92.1	63.8	98.2	ITM	74.8	88.3	61.6	99
CC4	73.9	92	30.4	100	IT5	70.6	86.3	61	98.4
Itarget1	78.4	94.9	26.3	100	Itarget1	69	88.5	31.3	100
Ltarget4	92.6	97.5	2.4	99.8	CC4	67.3	85.2	23.8	99.8
					Ltarget4	88.4	94.1	2.5	100

Results for each OM sorted by long-term yield (LTY)

Puerto Rico hogfish: MSE performance

	Base Stock					Alt Observation model			
	15% LH, Asymptotic selex					Imprecise, Biased			
MP	PNOF	B50	LTY	AAVY	MP	PNOF	B50	LTY	AAVY
Reference MP									
FMSYref	95.2	98.6	100	100	FMSYref	95.5	97.3	100	100
MPs producing 6 highest long-term yields that meet AP criteria									
DD4010	93.2	98.7	99	98.4	Islope1	55.2	76.8	71.2	93.4
DD	76.8	97.4	98.9	100	Islope4	56.3	76.8	65	93
EDCAC	57.9	96.9	97.4	58.4	LstepCC4	57.9	78.1	61.8	95.2
MCD	79	98.2	96.6	75.8	LstepCC1	57.9	78.3	59.8	95.6
Fratio	61.8	94.9	96	52	SPMSY	75.2	88.2	59.8	97
BK	79	95.1	93.5	59.2	IT5	64.1	82.5	57.2	96.8
Other MPs that meet AP criteria									
DCAC4010	92	98.6	91.5	68.4	IT10	67.1	85.5	56.4	98.2
Islope1	55.6	82.2	83	96.2	ITM	66.9	85	54.5	97.8
Islope4	57.3	82.1	80.2	96.2	Itarget1	67.9	83.8	28.3	71.2
IT10	69.1	91.5	79.8	98.8	CC4	62.1	79.6	26.9	84.2
ITM	68.8	91	78.3	98.8	Ltarget4	77.9	89.2	17.2	65.6
IT5	67	88.5	77.4	97					
LstepCC1	59.4	83.3	74.2	96.2					
LstepCC4	59.1	83.2	74.1	96.2					
SPMSY	80.5	92.1	63.8	98.2					
CC4	73.9	92	30.4	100					
Itarget1	78.4	94.9	26.3	100					
Ltarget4	92.6	97.5	2.4	99.8					

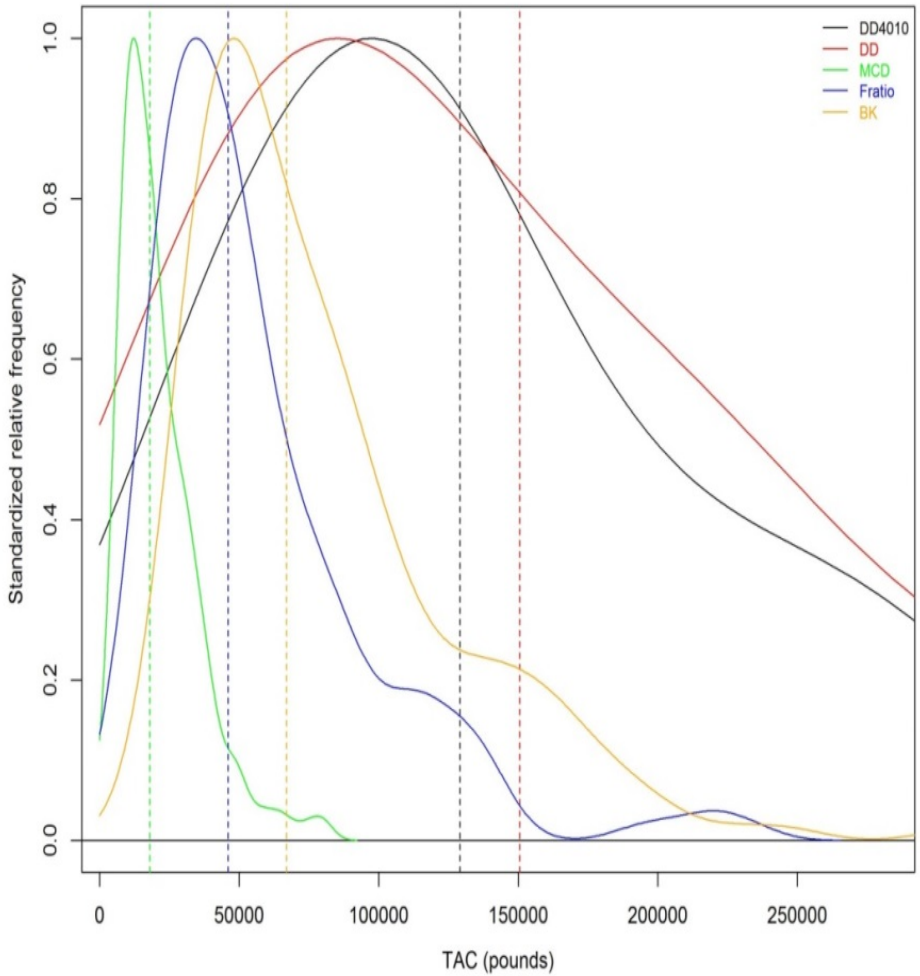
Results for each OM sorted by long-term yield (LTY)

Puerto Rico hogfish: Catch recommendations

- **MPs shown** for catch recommendations which:
  - Met performance criteria specified by SEDAR 46 DW/AW Panel
  - Produced the highest relative long-term yields in the MSE relative to the FMSYref

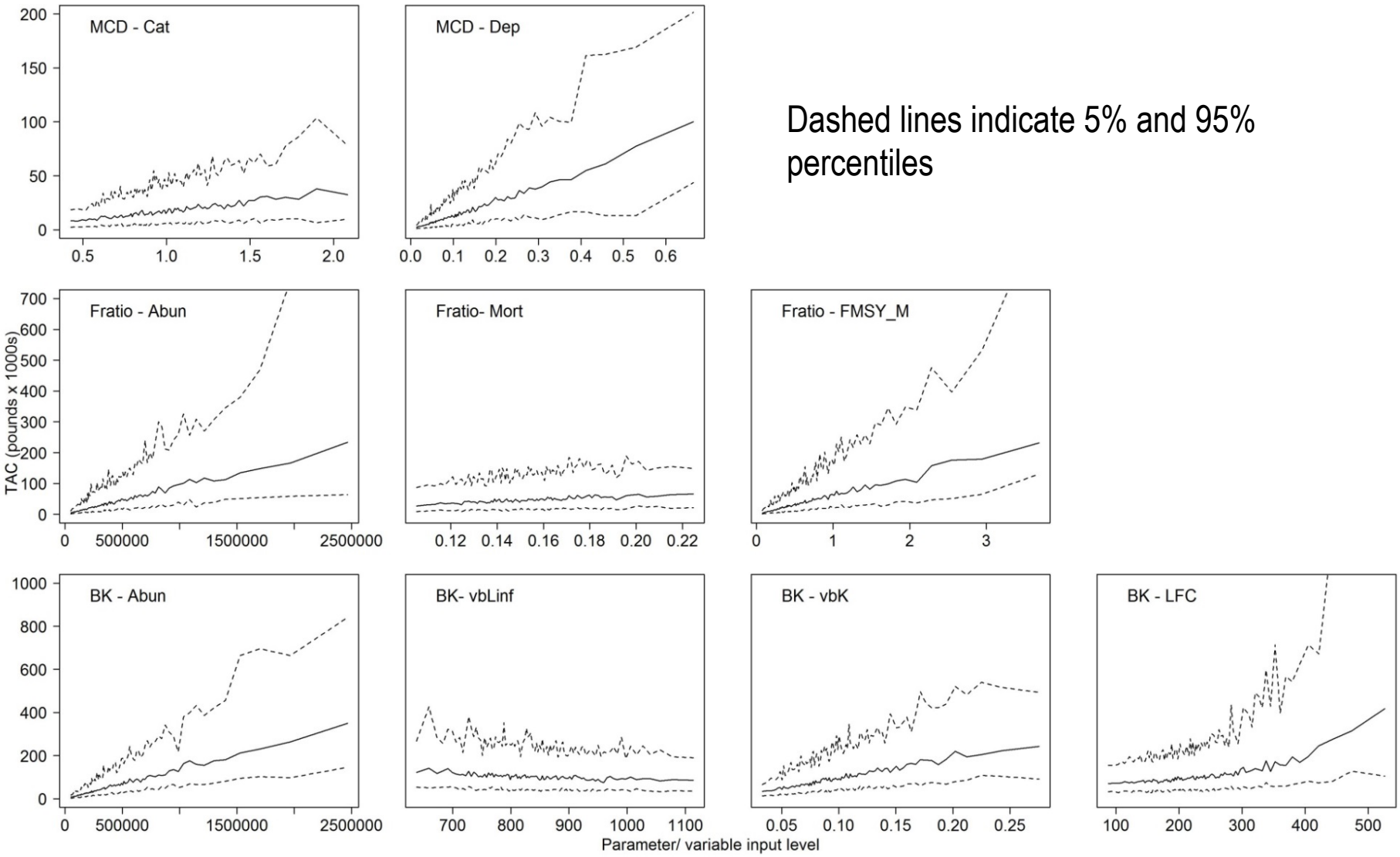
Puerto Rico hogfish: Catch recommendations

	Summary statistics (TACs, in pounds)				
MP	Min	25th Percentile	Median	75th Percentile	Max
MPs producing 6 highest long-term yields that meet AP criteria					
DD4010	3,637	68,551	123,440	282,430	2,948,048
DD	11,387	84,777	173,400	385,546	2,333,902
Fratio	6,936	28,000	44,959	68,063	245,645
MCD	1,652	11,404	17,283	24,213	63,112
BK	17,760	51,302	75,670	105,420	250,913
Other MPs that meet AP criteria					
Islope1	33,629	43,635	49,368	54,459	77,728
Islope4	23,369	33,215	37,415	41,354	53,197
SPMSY	1,880	17,922	34,898	48,329	74,192
CC4	27,654	37,053	41,262	45,919	66,965
Itarget1	30,163	37,885	41,765	47,914	59,958



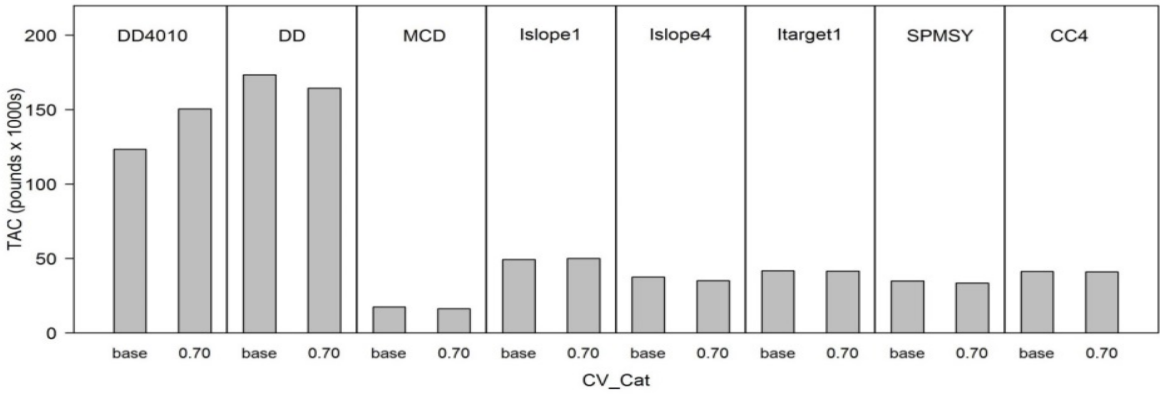
Dashed lines indicate median value for each MP

Puerto Rico hogfish: Real world catch sensitivity



Dashed lines indicate 5% and 95% percentiles

Puerto Rico hogfish: Catch sensitivity (cont'd)



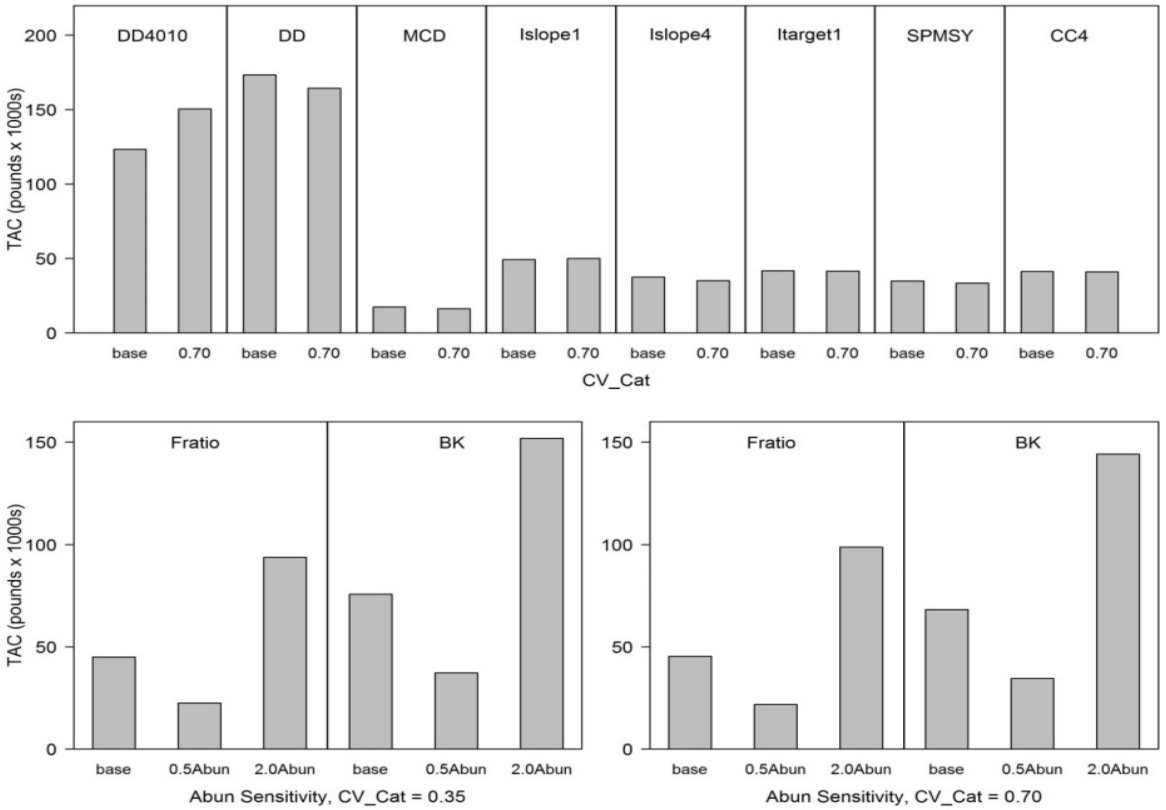
Sensitivities:

- CV_Catch = 0.35
  - 2 x CV_Catch (0.70)

Puerto Rico hogfish: Catch sensitivity (cont'd)

Sensitivities:

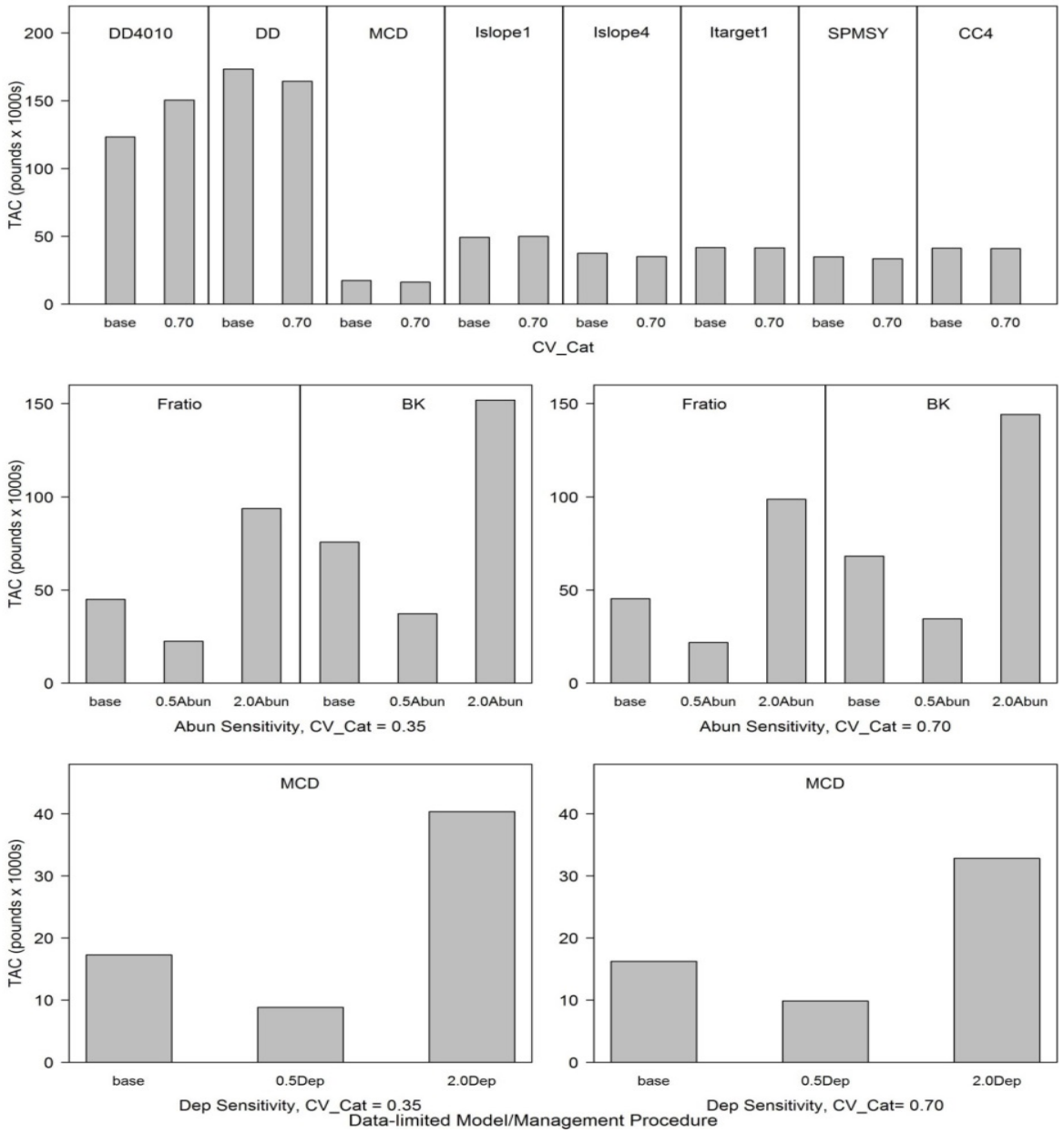
- CV_Catch = 0.35
  - 2 x CV_Catch (0.70)
- Abundance (501,235)
  - 2 x Abun
  - 0.5 x Abun



Puerto Rico hogfish: Catch sensitivity (cont'd)

Sensitivities:

- CV_Catch = 0.35
  - 2 x CV_Catch (0.70)
- Abundance (501,235)
  - 2 x Abun
  - 0.5 x Abun
- Depletion (0.135)
  - 2 X Dep
  - 0.5 x Dep



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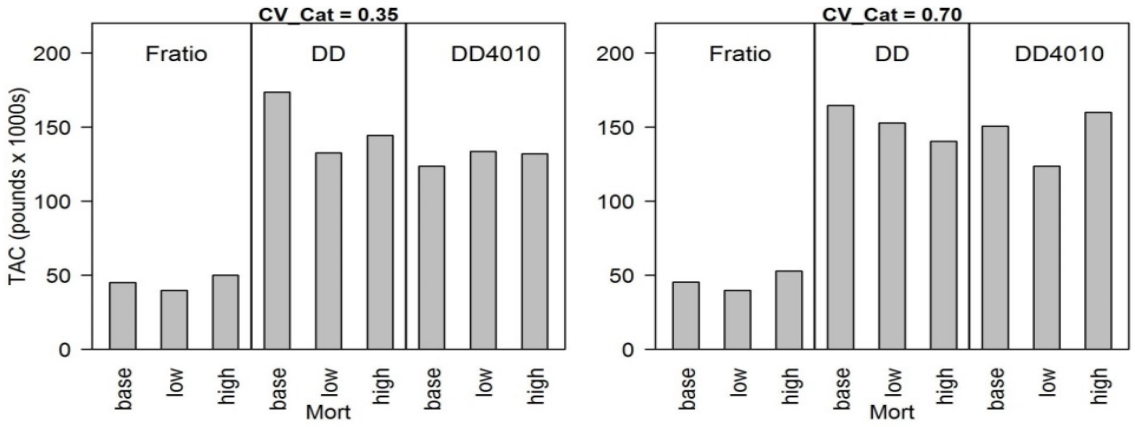


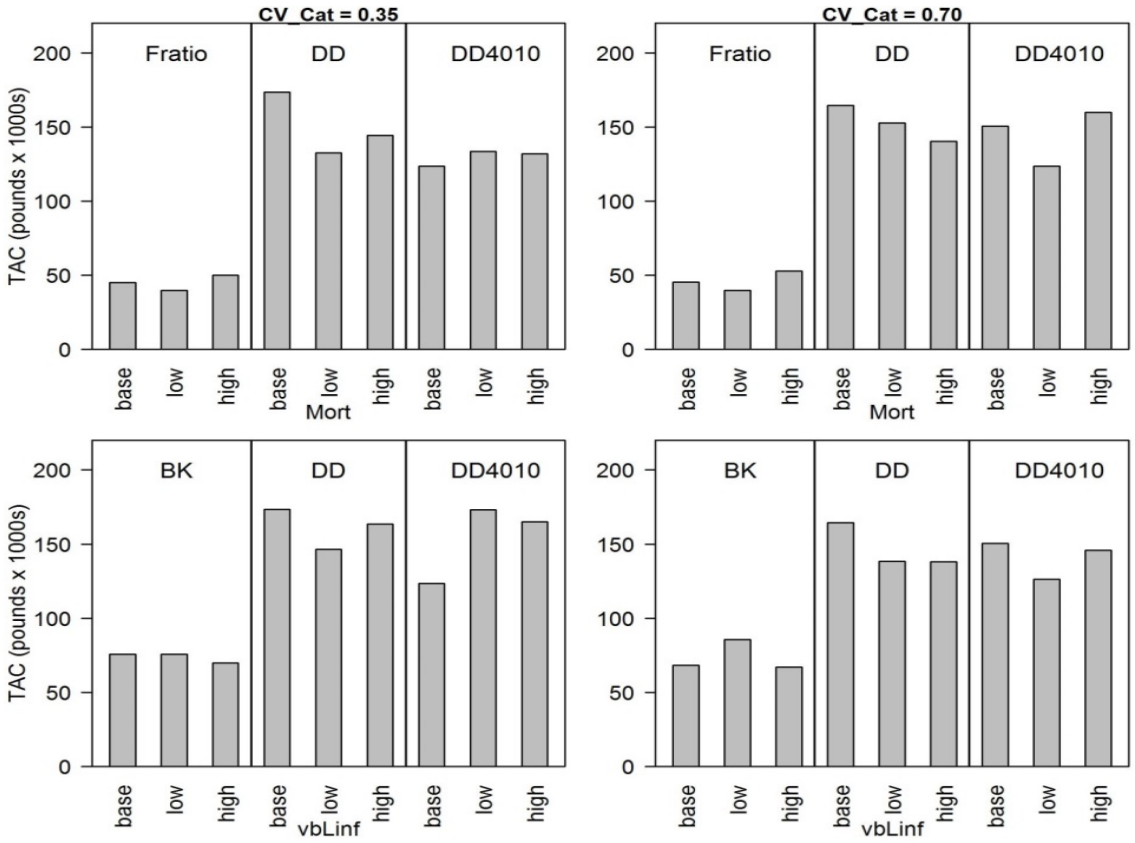
Sensitivities:

- CV_Catch = 0.35
  - 2 x CV_Catch (0.70)
- LH (low, base, high)
  - Mort (0.13, 0.16, 0.18)

Puerto Rico hogfish: Catch sensitivity (cont'd)

Sensitivities:

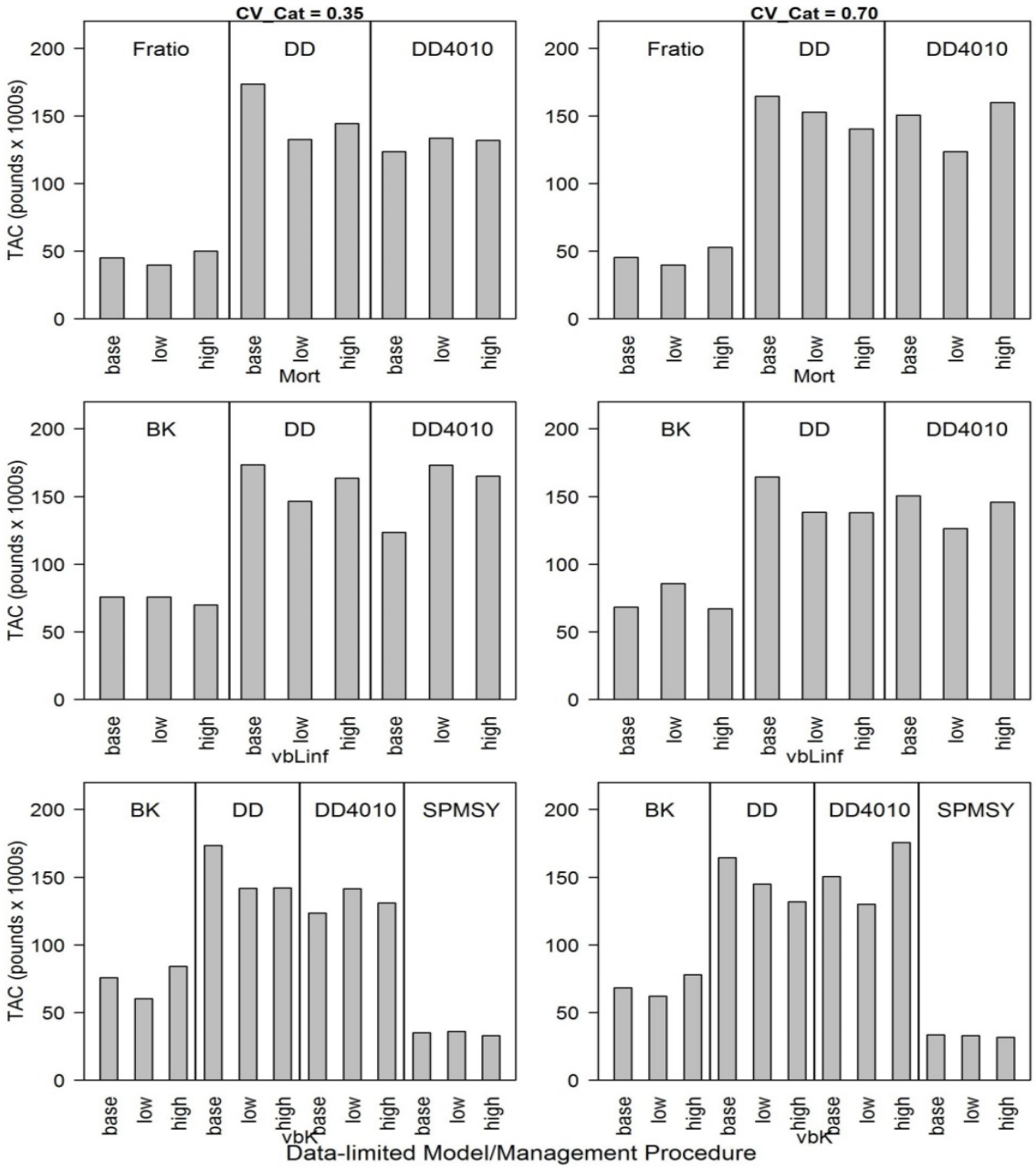
- CV_Catch = 0.35
  - 2 x CV_Catch (0.70)
- LH (low, base, high)
  - Mort (0.13, 0.16, 0.18)
  - vbLinf (722, 849, 976)



Puerto Rico hogfish: Catch sensitivity (cont'd)

Sensitivities:

- CV_Catch = 0.35
  - 2 x CV_Catch (0.70)
- LH (low, base, high)
  - Mort (0.13, 0.16, 0.18)
  - vbLinf (722, 849, 976)
  - vbK (0.09, 0.11, 0.12)



Puerto Rico hogfish: Guidance table for comparing MPs

Considerations important in selecting between MPs:

- Performance metrics (PNOF, B50, LTY, AAVY) by method type:
  - Abundance-based
  - Depletion-based
  - Data moderate
  - Index-based
  - Catch-based
- Life history inputs (e.g., spatial relevance, confidence in estimates)
- Data inputs (bias in catch, selectivity, index of abundance, fleet representativeness)

Puerto Rico hogfish: Guidance table

Considerations:

- Performance metrics

Parameter	Abun-based		Dep-based	Data-moderate		Index-based			Catch-based	
	Fratio	BK	MCD	DD	DD4010	Islope1	Islope4	Itarget1	SPMSY	CC4
PNOF	61.8	79	79	76.8	93.2	55.6	57.3	78.4	80.5	73.9
B50	94.9	95.1	98.2	97.4	98.7	82.2	82.1	94.9	92.1	92
LTY	96	93.5	96.6	98.9	99	83	80.2	26.3	63.8	30.4
AAVY	52	59.2	75.8	100	98.4	96.2	96.2	100	98.2	100
Mort	Known, constant across age			Known, constant across age						
L50				Uncertainty from protogyny					Uncertainty from protogyny	
vbt0				Growth characterizations reflective of PR					Life history characterizations reflective of PR	
vbK		Life history characterizations reflective of PR								
vbLinf										
wla										
wlb										
Maxage				Age characterizations reflective of PR					Age characterizations reflective of PR	
Cat			Known, informative of historical removals							
LFC		TIP sampling representative of selectivity								
FMSY_M	Known									
Ind				Fishery dependent representative of population abundance, dependent upon accurate effort reporting						
Dep			Known, estimated from TIP samples and life history							
Abun	Known, estimated from current catch and F									

Puerto Rico hogfish: Guidance table

Considerations:

- LH parameters derived from South Atlantic
- Hermaphroditism

Parameter	Abun-based		Dep-based	Data-moderate		Index-based			Catch-based	
	Fratio	BK	MCD	DD	DD4010	Islope1	Islope4	Itarget1	SPMSY	CC4
PNOF	61.8	79	79	76.8	93.2	55.6	57.3	78.4	80.5	73.9
B50	94.9	95.1	98.2	97.4	98.7	82.2	82.1	94.9	92.1	92
LTY	96	93.5	96.6	98.9	99	83	80.2	26.3	63.8	30.4
AAVY	52	59.2	75.8	100	98.4	96.2	96.2	100	98.2	100
Mort	Known, constant across age			Known, constant across age						
L50				Uncertainty from protogyny					Uncertainty from protogyny	
vbt0				Growth characterizations reflective of PR					Life history characterizations reflective of PR	
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Ind				Fishery dependent representative of population abundance, dependent upon accurate effort reporting						
Dep			Known, estimated from TIP samples and life history							
Abun	Known, estimated from current catch and F									

Puerto Rico hogfish: Guidance table

Considerations:

- Underreporting of catch
- Representativeness of fleet: selectivity & index of abundance

Parameter	Abun-based		Dep-based	Data-moderate		Index-based			Catch-based	
	Fratio	BK	MCD	DD	DD4010	Islope1	Islope4	Itarget1	SPMSY	CC4
PNOF	61.8	79	79	76.8	93.2	55.6	57.3	78.4	80.5	73.9
B50	94.9	95.1	98.2	97.4	98.7	82.2	82.1	94.9	92.1	92
LTY	96	93.5	96.6	98.9	99	83	80.2	26.3	63.8	30.4
AAVY	52	59.2	75.8	100	98.4	96.2	96.2	100	98.2	100
Mort	Known, constant across age			Known, constant across age						
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vbt0				Growth characterizations reflective of PR					Life history characterizations reflective of PR	
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FMSY_M	Known									
Ind				Fishery dependent representative of population abundance, dependent upon accurate effort reporting						
Dep			Known, estimated from TIP samples and life history							
Abun	Known, estimated from current catch and F									

Puerto Rico hogfish: Guidance table

Considerations:

- Highly uncertain estimates of depletion and current abundance

Parameter	Abun-based		Dep-based	Data-moderate		Index-based			Catch-based	
	Fratio	BK	MCD	DD	DD4010	Islope1	Islope4	Itarget1	SPMSY	CC4
PNOF	61.8	79	79	76.8	93.2	55.6	57.3	78.4	80.5	73.9
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Ind				Fishery dependent representative of population abundance, dependent upon accurate effort reporting						
Dep			Known, estimated from TIP samples and life history							
Abun	Known, estimated from current catch and F									

Puerto Rico hogfish: summary

- Tradeoffs between MPs highlight the importance of selecting performance criteria
- Considerable uncertainty present in data inputs for US Caribbean species highlights caution when selecting MPs for management advice

Puerto Rico hogfish assessment summary

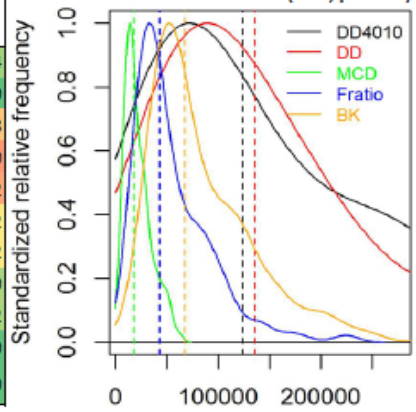
Hogfish (*Lachnolaimus maximus*) Puerto Rico Diving

Management Evaluation Performance Results

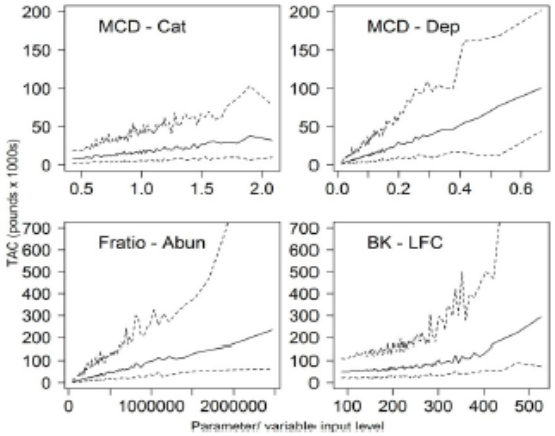
Ordered by PNOF				Ordered by LTY			
No	MP	PNOF	B50	No	MP	LTY	AAVY
1	DD4010	93.2	98.7	1	DD4010	99.0	98.4
2	SPMSY	80.5	92.1	2	DD	98.9	100.0
3	BK	79.0	95.1	3	MCD	96.6	75.8
4	MCD	79.0	98.2	4	Fratio	96.0	52.0
5	Itarget1	78.4	94.9	5	BK	93.5	59.2
6	DD	76.8	97.4	6	Islope1	83.0	96.2
7	CC4	73.9	92.0	7	Islope4	80.2	96.2
8	YPR_ML	70.0	84.0	8	YPR_ML	77.0	78.0
9	Fratio	61.8	94.9	9	SPMSY	63.8	98.2
10	Islope4	57.3	82.1	10	CC4	30.4	100.0
11	Islope1	55.6	82.2	11	Itarget1	26.3	100.0

PNOF = Prob. of not overfishing (%); **B50** = Prob. of B being above 0.5 BMSY (%); **LTY** = Relative long-term yield (fraction of simulations achieving > 50% FMSY yield over final 10 projection years); **AAVY** = fraction of simulations where average annual variability in yield < 15%

Distributions and Medians (dashed) for DLMtool Total Allowable Catch (TAC; pounds)



Subset of Catch Statistics Sensitivities:



DLMtool Catch Statistics (lbs)

MP	Min	Median	Max
Highest long-term yields in MSE			
DD4010	3,637	123,440	2,948,048
DD	11,387	173,400	2,333,902
Fratio	6,936	44,959	245,645
MCD	1,652	17,283	63,112
BK	17,760	75,670	250,913
Other MPs that meet AP criteria			
Islope1	33,629	49,368	77,728
Islope4	23,369	37,415	53,197
SPMSY	1,880	34,898	74,192
CC4	27,654	41,262	66,965
Itarget1	30,163	41,765	59,958

Mean length estimator (Huynh)	
YPR_ML (F0.1)	45,791

Catch Statistics (lbs)			
Catch	35,297	65,754	131,073
2014 Catch			58,569
2012–2014 Average Catch			59,946
1983-2014 Average Catch			70,634

Concerns and Caveats:

- **Method-specific assumptions** (e.g., constant M)
- **Sensitivity to data inputs**: life history parameters, depletion, and abundance
- **Data quality**: **life history parameters** derived from South Atlantic; hermaphroditic; underreporting of **catch**; Appropriateness of fishery-dependent **index of abundance**, estimates of **stock depletion** and **current abundance**, appropriateness of TIP data in quantifying **length at first capture**

Considerations:

- Exclude MPs with catch recommendations near or exceeding maximum observed catches (DD/DD4010)
- Weigh trade-offs in metrics and data quality

Results

- Species: yellowtail snapper
- Island: Puerto Rico
- Gear: handline

Content:

- MSE
  - Operating model
  - Convergence
  - Tradeoffs & performance
- Catch calculations
- Catch sensitivities
- Guidance

Photo from NOAA Photo Library (http://www.photolib.noaa.gov/).

Puerto Rico yellowtail snapper: Operating model (OM)

Base OM:

- Stock (15% variability)
- Fleet (Asymptotic)
- Observation model (precise, unbiased)

Alternative OMs:

- Stock (5% variability)
- Fleet (Asymptotic)
- Observation model (imprecise, biased)

Puerto Rico yellowtail snapper: MSE performance results

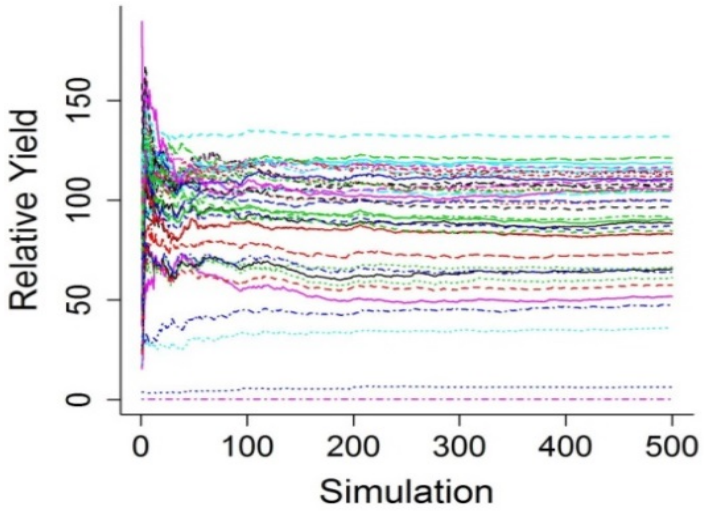
- Model convergence
- Tradeoff plots allow comparison of performance of feasible management procedures (MPs) between base and alternative OMs
  - Feasibility defined by data sufficiency
  - Sensitivity to assumptions made within OM components (stock, observation model inputs)
    - Life history
    - Bias and quality of data inputs

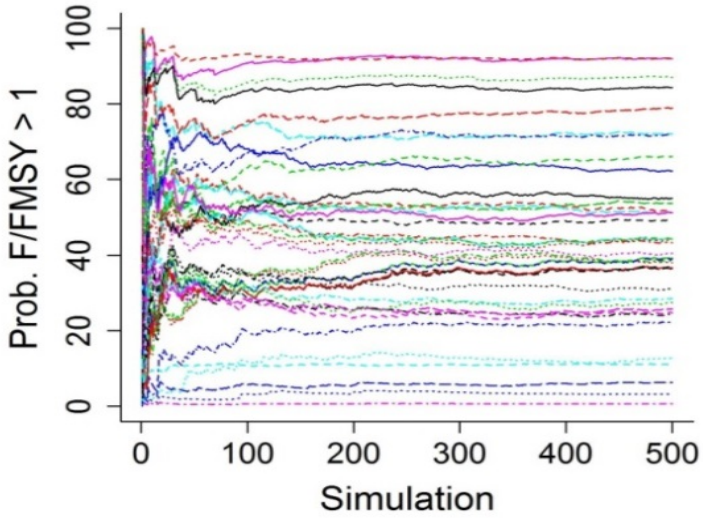
Puerto Rico yellowtail snapper: Model convergence

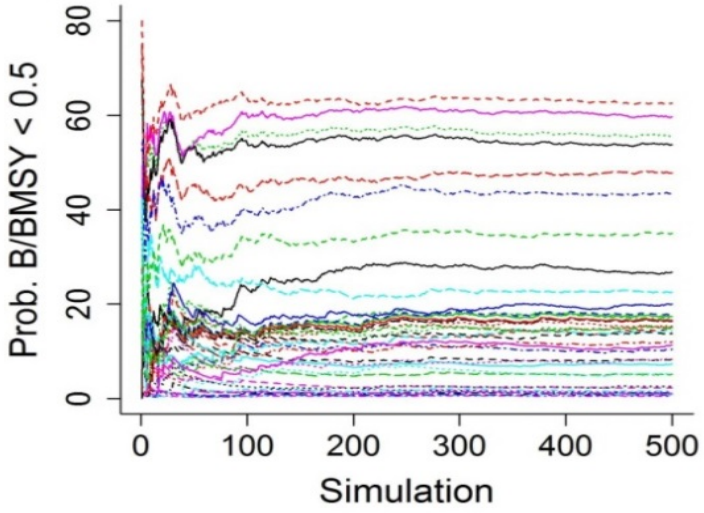
Assumes:

- Base stock, fleet, and subclass OM scenarios

- n=500 sims, 250 reps







All MPs converged at threshold = 1%

Most MPs converged by ~ 300 simulations

Puerto Rico yellowtail snapper: Tradeoffs in performance by MP

Assumes:

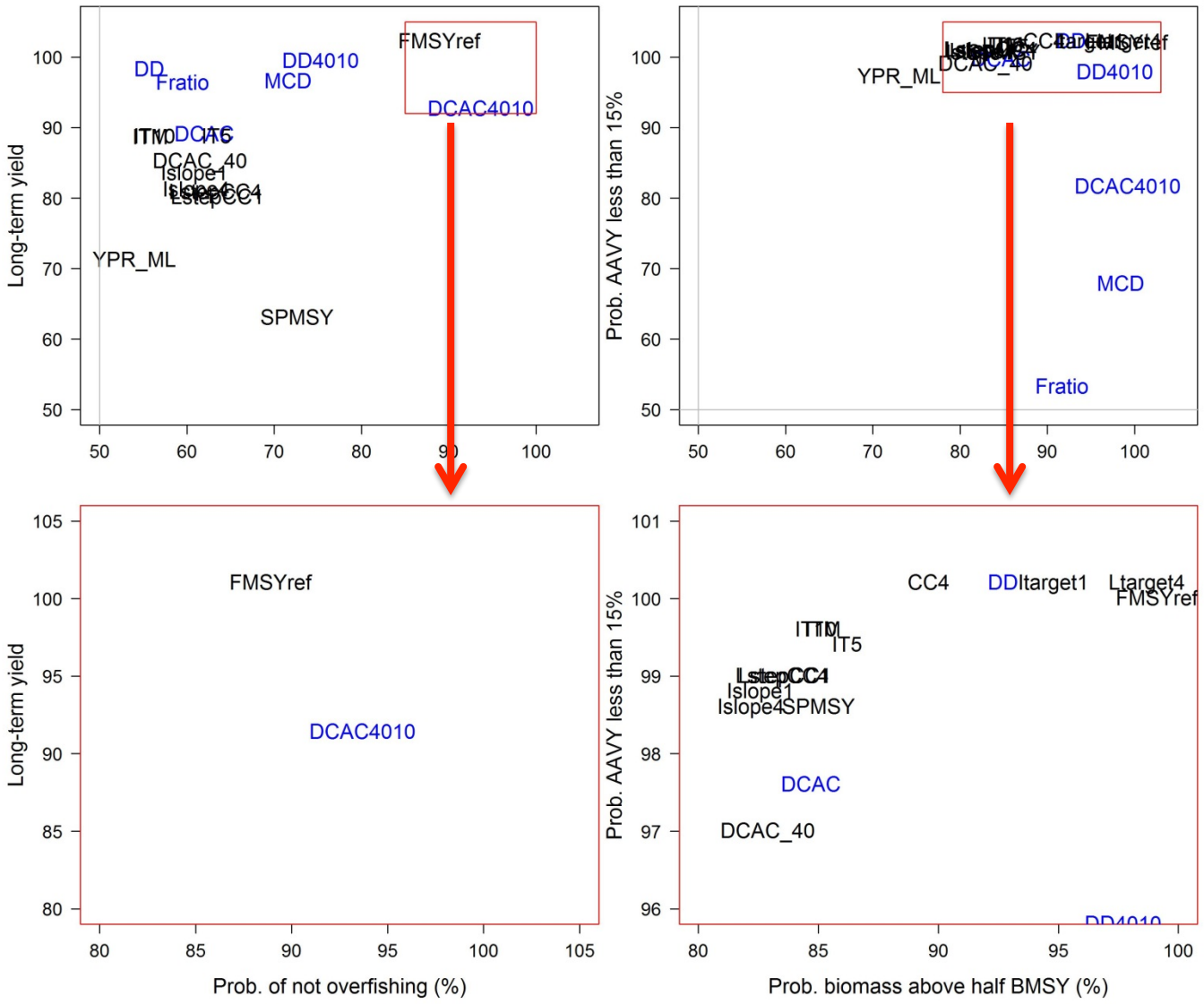
- Base stock, fleet, and subclass OM Scenarios

Long-term yield:

- Fraction of simulations achieving over 50% FMSY yield over the final 10 years of the projection

FMSYref:

- Assumes perfect information



Puerto Rico yellowtail snapper: MSE performance

	Base Stock					Alt Stock			
	15%LH, Asymptotic selex					5%LH, Asymptotic selex			
MP	PNOF	B50	LTY	AAVY	MP	PNOF	B50	LTY	AAVY
Reference MP									
FMSYref	88.9	99.1	100	99.8	FMSYref	89.4	99.1	100	100
MPs producing 6 highest long-term yields that meet AP criteria									
DD4010	75.3	97.7	97.2	95.6	DD4010	82.9	98	98.1	97
DD	55.7	92.7	96	100	DD	60	93.2	97.4	100
MCD	71.6	98.4	94.3	65.6	MCD	71.3	98.4	96	67.4
Fratio	59.5	91.7	94.1	51	Fratio	59.1	91.8	94.8	51
DCAC4010	93.7	99.2	90.4	79.4	DCAC4010	92.8	99.2	92	74.8
DCAC	62	84.7	86.8	97.4	IT5	61.1	84.5	87.7	98.8
Other MPs producing lower long-term yields that met AP criteria									
IT5	63.4	86.2	86.5	99.2	ITM	56.6	84.6	86.9	99.2
IT10	56.3	84.9	86.5	99.4	IT10	56.3	84.8	86.8	99.2
ITM	55.8	85.2	86.4	99.4	DCAC	53.2	81.5	85.5	97.8
DCAC_40	61.5	82.9	83	96.8	Islope1	54.9	79.5	82.1	98.2
Islope1	60.9	82.6	81.3	98.6	DCAC_40	52.2	79.3	81.3	96.6
Islope4	61.1	82.2	79	98.4	Islope4	55.4	79.2	81.3	98
LstepCC4	63.3	83.5	78.6	98.8	LstepCC1	57.6	80.4	79	98.2
LstepCC1	63.5	83.6	77.9	98.8	LstepCC4	57.6	80.5	78.7	98.2
SPMSY	72.6	85	60.8	98.4	SPMSY	71.8	83	63.7	98.4
CC4	77.6	89.6	32.2	100	CC4	74.8	87.9	36.5	100
Itarget1	87.3	94.8	22.2	100	Itarget1	85.3	94.4	24.8	100
Ltarget4	96.7	98.7	1.2	100	Ltarget4	96.2	98.5	0.7	100

Results for each OM sorted by long-term yield (LTY)

Puerto Rico yellowtail snapper: MSE performance

	Base Stock					Alt Observation model			
	15%LH, Asymptotic selex					Imprecise, Biased			
MP	PNOF	B50	LTY	AAVY	MP	PNOF	B50	LTY	AAVY
Reference MP						PNOF	B50	LTY	VY
FMSYref	88.9	99.1	100	99.8	FMSYref	89.7	99.1	100	100
MPs producing 6 highest long-term yields that meet AP criteria									
DD4010	75.3	97.7	97.2	95.6	DCAC	56.9	79.4	77.1	90.6
DD	55.7	92.7	96	100	Islope1	57.8	77.9	72.6	94.4
MCD	71.6	98.4	94.3	65.6	DCAC_40	58.2	78.8	72.2	95.6
Fratio	59.5	91.7	94.1	51	Islope4	58.1	77.7	70.5	94.2
DCAC4010	93.7	99.2	90.4	79.4	IT5	60.5	80	69.3	96.8
DCAC	62	84.7	86.8	97.4	IT10	57.2	80	69.2	97.4
Other MPs producing lower long-term yields that met AP criteria									
IT5	63.4	86.2	86.5	99.2	ITM	57.4	79.9	69.2	97.2
IT10	56.3	84.9	86.5	99.4	LstepCC4	60.3	79.3	67.5	96.4
ITM	55.8	85.2	86.4	99.4	LstepCC1	60.7	79.3	67	96
DCAC_40	61.5	82.9	83	96.8	SPMSY	79.9	88	53.1	96.6
Islope1	60.9	82.6	81.3	98.6	CC4	64.6	78.5	27.8	83.2
Islope4	61.1	82.2	79	98.4	Itarget1	73.2	86	25.5	73.2
LstepCC4	63.3	83.5	78.6	98.8	Ltarget4	84	91.1	15.4	67.8
LstepCC1	63.5	83.6	77.9	98.8					
SPMSY	72.6	85	60.8	98.4					
CC4	77.6	89.6	32.2	100					
Itarget1	87.3	94.8	22.2	100					
Ltarget4	96.7	98.7	1.2	100					

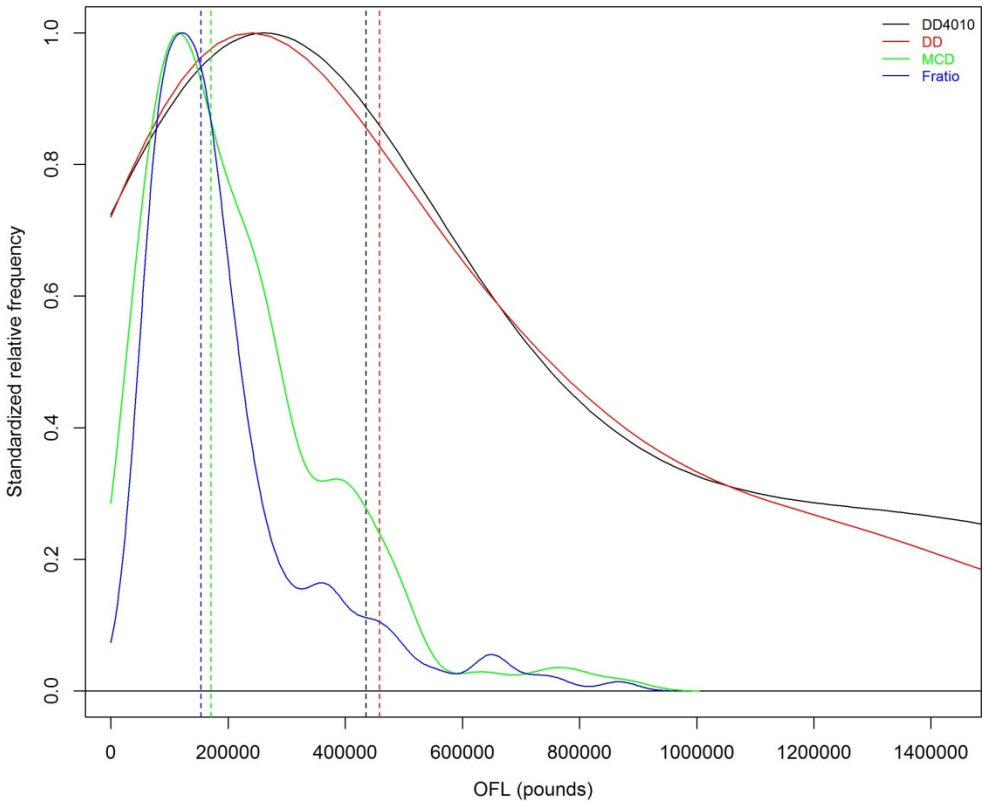
Results for each OM sorted by long-term yield (LTY)

Puerto Rico yellowtail snapper: Catch recommendations

- **MPs shown** for catch recommendations which:
  - Met performance criteria of the SEDAR 46 DW/AW Panel
  - Produced the highest relative long-term yields in the MSE relative to the FMSYref

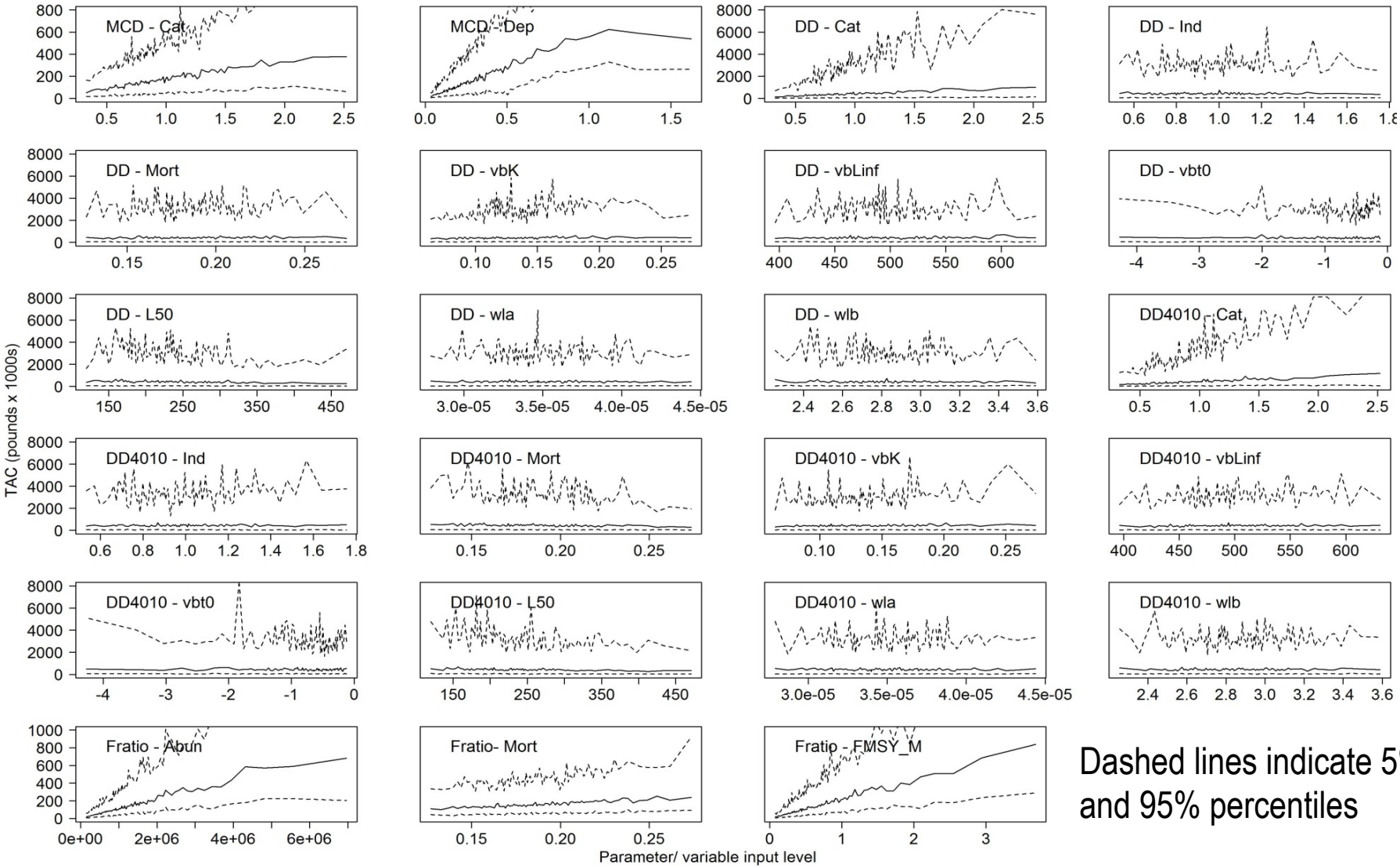
Puerto Rico yellowtail snapper: Catch recommendations

	Summary statistics (TACs, in pounds)				
MP	Min	25th Percentile	Median	75th Percentile	Max
MPs producing 6 highest long-term yields that meet AP criteria					
DD4010	27,628	223,580	450,093	1,097,725	5,924,792
DD	11,424	155,288	368,194	946,563	7,153,145
MCD	8,006	108,531	189,991	287,409	759,445
Fratio	32,926	99,141	156,541	236,985	732,805
Other MPs that meet AP criteria					
Islope1	78,516	134,495	157,096	177,837	247,785
Itarget1	68,293	115,929	132,242	151,066	229,522
CC4	72,870	115,029	129,130	153,585	265,171
SPMSY	4,232	77,414	125,071	169,584	255,162
Islope4	69,387	99,364	112,336	129,604	185,335



Dashed lines indicate median value for each MP

Puerto Rico yellowtail snapper: Real world catch sensitivity

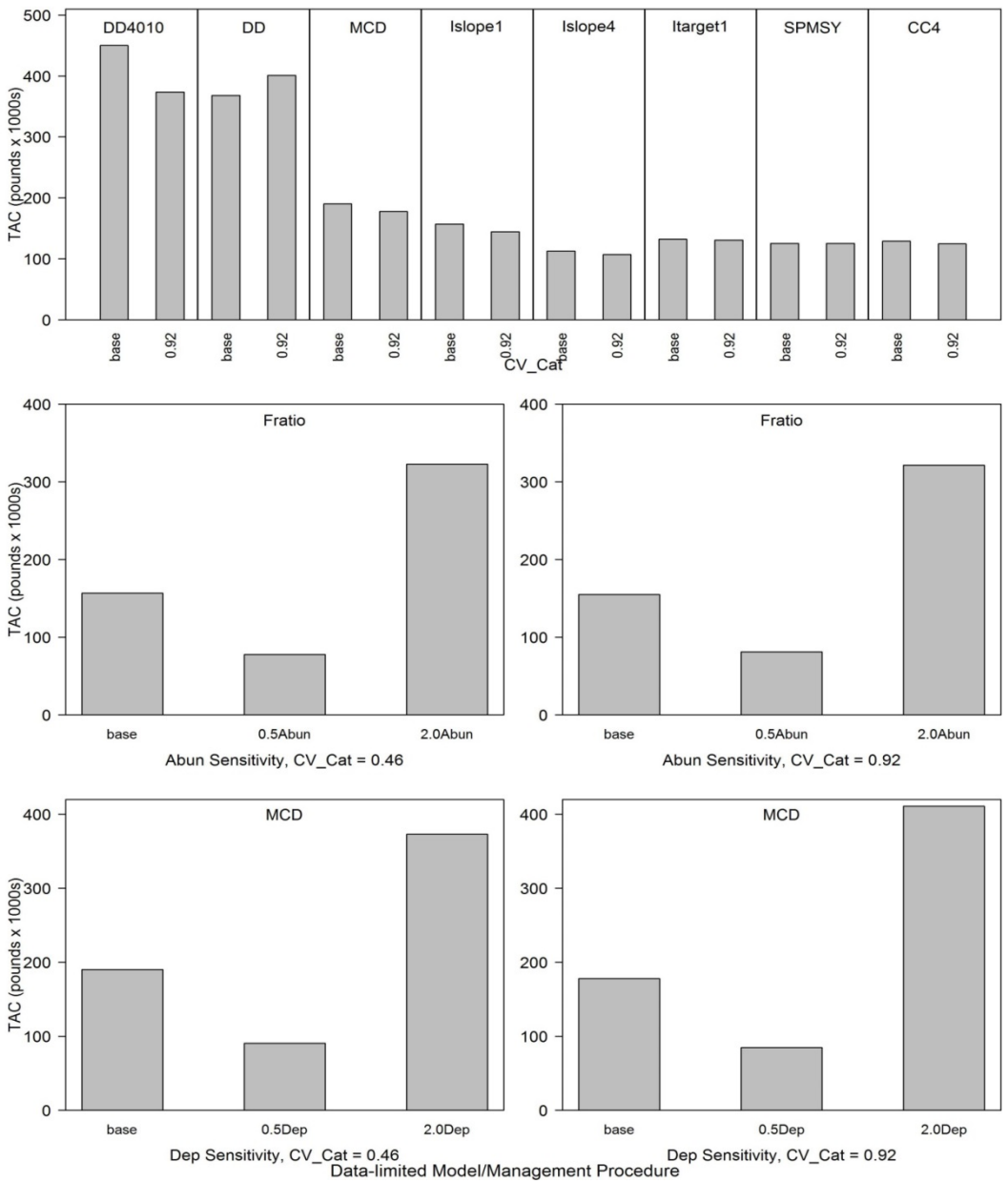


Dashed lines indicate 5% and 95% percentiles

Puerto Rico yellowtail snapper: Catch sensitivity (cont'd)

Sensitivities:

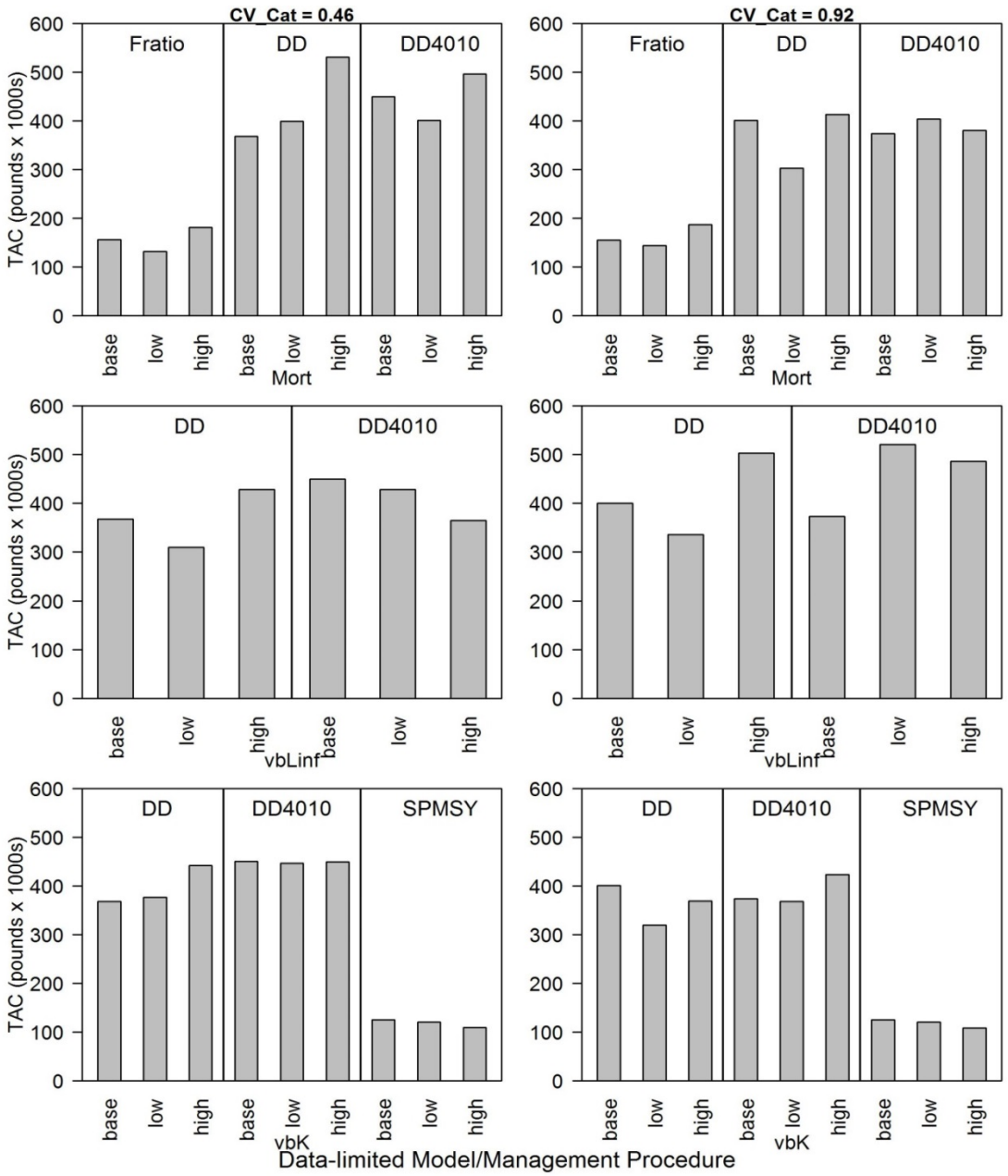
- CV_Catch = 0.46
  - 2 x CV_Catch (0.92)
- Abundance (1,416,390)
  - 2 x Abun
  - 0.5 x Abun
- Depletion (0.33)
  - 2 X Dep
  - 0.5 x Dep



Puerto Rico yellowtail snapper: Catch sensitivity (cont'd)

Sensitivities:

- CV_Catch = 0.46
  - 2 x CV_Catch (0.92)
- LH (low, base, high)
  - Mort (0.16, 0.19, 0.22)
  - vbLinf (427, 502, 578)
  - vbK (0.12, 0.14, 0.16)



Puerto Rico yellowtail snapper: Guidance table for comparing MPs

Considerations important in selecting between MPs:

- Performance metrics (PNOF, B50, LTY, AAVY) by method type:
  - Abundance-based
  - Depletion-based
  - Data moderate
  - Index-based
  - Catch-based
- Life history inputs (e.g., spatial relevance, confidence in estimates)
- Data inputs (bias in catch, selectivity, index of abundance, fleet representativeness)

Puerto Rico yellowtail snapper: Guidance table

Considerations:

- Performance metrics

Parameter	Abun-based	Dep-based	Data-moderate		Index-based			Catch-based	
	Fratio	MCD	DD	DD4010	Islope1	Islope4	Itarget1	SPMSY	CC4
PNOF	59.5	71.6	55.7	75.3	60.9	61.1	87.3	72.6	77.6
B50	91.7	98.4	92.7	97.7	82.6	82.2	94.8	85	89.6
LTY	94.1	94.3	96	97.2	81.3	79	22.2	60.8	32.2
AAVY	51	65.6	100	95.6	98.6	98.4	100	98.4	100
Mort	Known, Constant across age		Known, constant across age						
L50			Life history characterizations reflective of PR					Life history characterizations reflective of PR	
vbt0									
vbK									
vbLinf									
wla									
wlb									
Maxage			Age characterizations reflective of PR					Age characterizations reflective of PR	
Cat		Known, informative of historical removals							
FMSY_M	Known								
Ind			Fishery dependent representative of population abundance, dependent upon accurate effort reporting						
Dep		Known, estimated from TIP samples and life history							
Abun	Known, estimated from current catch and F								

Puerto Rico yellowtail snapper: Guidance table

Considerations:

- MaxAge and Mort from Central Brazil

Parameter	Abun-based	Dep-based	Data-moderate		Index-based			Catch-based	
	Fratio	MCD	DD	DD4010	Islope1	Islope4	Itarget1	SPMSY	CC4
PNOF	59.5	71.6	55.7	75.3	60.9	61.1	87.3	72.6	77.6
B50	91.7	98.4	92.7	97.7	82.6	82.2	94.8	85	89.6
LTY	94.1	94.3	96	97.2	81.3	79	22.2	60.8	32.2
AAVY	51	65.6	100	95.6	98.6	98.4	100	98.4	100
Mort	Known, Constant across age		Known, constant across age						
L50			Life history characterizations reflective of PR					Life history characterizations reflective of PR	
vbt0									
vbK									
vbLinf									
wla									
wlb									
Maxage			Age characterizations reflective of PR					Age characterizations reflective of PR	
Cat		Known, informative of historical removals							
FMSY_M	Known								
Ind			Fishery dependent representative of population abundance, dependent upon accurate effort reporting						
Dep		Known, estimated from TIP samples and life history							
Abun	Known, estimated from current catch and F								

Puerto Rico yellowtail snapper: Guidance table

Considerations:

- Underreporting of catch & inconsistencies
- Representativeness of fleet: index of abundance

Parameter	Abun-based	Dep-based	Data-moderate		Index-based			Catch-based	
	Fratio	MCD	DD	DD4010	Islope1	Islope4	Itarget1	SPMSY	CC4
PNOF	59.5	71.6	55.7	75.3	60.9	61.1	87.3	72.6	77.6
B50	91.7	98.4	92.7	97.7	82.6	82.2	94.8	85	89.6
LTY	94.1	94.3	96	97.2	81.3	79	22.2	60.8	32.2
AAVY	51	65.6	100	95.6	98.6	98.4	100	98.4	100
Mort	Known, Constant across age		Known, constant across age						
L50			Life history characterizations reflective of PR					Life history characterizations reflective of PR	
vbt0									
vbK									
vbLinf									
wla									
wlb									
Maxage			Age characterizations reflective of PR					Age characterizations reflective of PR	
Cat		Known, informative of historical removals							
FMSY_M	Known								
Ind			Fishery dependent representative of population abundance, dependent upon accurate effort reporting						
Dep		Known, estimated from TIP samples and life history							
Abun	Known, estimated from current catch and F								

Puerto Rico yellowtail snapper: Guidance table

Considerations:

- Highly uncertain estimates of depletion and current abundance

Parameter	Abun-based	Dep-based	Data-moderate		Index-based			Catch-based	
	Fratio	MCD	DD	DD4010	Islope1	Islope4	Itarget1	SPMSY	CC4
PNOF	59.5	71.6	55.7	75.3	60.9	61.1	87.3	72.6	77.6
B50	91.7	98.4	92.7	97.7	82.6	82.2	94.8	85	89.6
LTY	94.1	94.3	96	97.2	81.3	79	22.2	60.8	32.2
AAVY	51	65.6	100	95.6	98.6	98.4	100	98.4	100
Mort	Known, Constant across age		Known, constant across age						
L50			Life history characterizations reflective of PR					Life history characterizations reflective of PR	
vbt0									
vbK									
vbLinf									
wla									
wlb									
Maxage			Age characterizations reflective of PR					Age characterizations reflective of PR	
Cat		Known, informative of historical removals							
FMSY_M	Known								
Ind			Fishery dependent representative of population abundance, dependent upon accurate effort reporting						
Dep		Known, estimated from TIP samples and life history							
Abun	Known, estimated from current catch and F								

Puerto Rico yellowtail snapper: summary

- Tradeoffs between MPs highlight the importance of selecting performance criteria
- Considerable uncertainty present in data inputs for US Caribbean species highlights caution when selecting MPs for management advice

Puerto Rico yellowtail snapper assessment summary

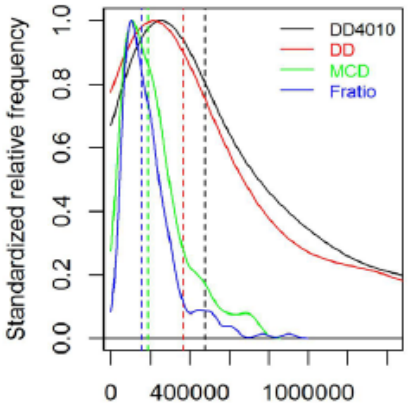
Yellowtail snapper (*Ocyurus chrysurus*) Puerto Rico Handline

Management Evaluation Performance Results

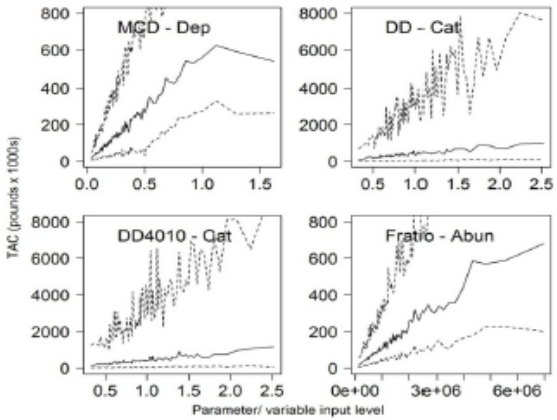
Ordered by PNOF				Ordered by LTY			
No	MP	PNOF	B50	No	MP	LTY	AAVY
1	Itarget1	87.3	94.8	1	DD4010	97.2	95.6
2	CC4	77.6	89.6	2	DD	96.0	100.0
3	DD4010	75.3	97.7	3	MCD	94.3	65.6
4	SPMSY	72.6	85.0	4	Fratio	94.1	51.0
5	MCD	71.6	98.4	5	Islope1	81.3	98.6
6	Islope4	61.1	82.2	6	Islope4	79.0	98.4
7	Islope1	60.9	82.6	7	YPR_ML	77.0	78.0
8	Fratio	59.5	91.7	8	SPMSY	60.8	98.4
9	DD	55.7	92.7	9	CC4	32.2	100.0
10	YPR_ML	54.0	73.0	10	Itarget1	22.2	100.0

PNOF = Prob. of not overfishing (%); **B50** = Prob. of B being above 0.5 BMSY (%); **LTY** = Relative long-term yield (fraction of simulations achieving > 50% FMSY yield over final 10 projection years); **AAVY** = fraction of simulations where average annual variability in yield < 15%

Distributions and Medians (dashed) for DLMtool Total Allowable Catch (TAC; pounds)



Subset of Catch Statistics Sensitivities:



DLMtool Catch Statistics (lbs)			
MP	Min	Median	Max
Highest long-term yields in MSE			
DD4010	27,628	450,093	5,924,792
DD	11,424	368,194	7,153,145
MCD	8,006	189,991	759,445
Fratio	32,926	156,541	732,805
Other MPs that meet AP criteria			
Islope1	78,516	157,096	247,785
Itarget1	68,293	132,242	229,522
CC4	72,870	129,130	265,171
SPMSY	4,232	125,071	255,162
Islope4	69,387	112,336	185,335

Mean length estimator (Huynh)	
YPR_ML (F0.1)	201,354

Catch Statistics (lbs)			
Catch	122,999	277,810	688,908
2014 Catch			200,667
2012–2014 Average Catch			186,790
1983-2014 Average Catch			297,299

Concerns and Caveats:

- **Method-specific assumptions** (e.g., constant M)
- **Sensitivity to data inputs**: life history parameters, depletion, and abundance
- **Data quality**: **life history parameters** derived from Brazil; underreporting of **catch** and inconsistency in recording snappers in data files; Appropriateness of fishery-dependent **index of abundance**, estimates of **stock depletion** and **current abundance**, appropriateness of TIP data in quantifying **length at first capture**

Considerations:

- Exclude MPs with catch recommendations near or exceeding maximum observed catches (DD4010)
- Consider methods with high PNOF and LTY and weigh trade-offs in metrics

Results

Photo from NOAA Photo Library (http://www.photolib.noaa.gov/).

- Species: queen triggerfish
- Island: St. Thomas/St. John
- Gear: pots and traps

Content:

- MSE
  - Operating model
  - Convergence
  - Tradeoffs & performance
- Catch calculations
- Catch sensitivities
- Guidance

St. Thomas queen triggerfish: Operating model (OM)

Base OM:

- Stock (15% variability)
- Fleet (High Dome)
- Observation model (precise, unbiased)

Alternative OMs:

- Stock (5% variability)
- Fleet (Moderate Dome)
- Observation model (imprecise, biased)

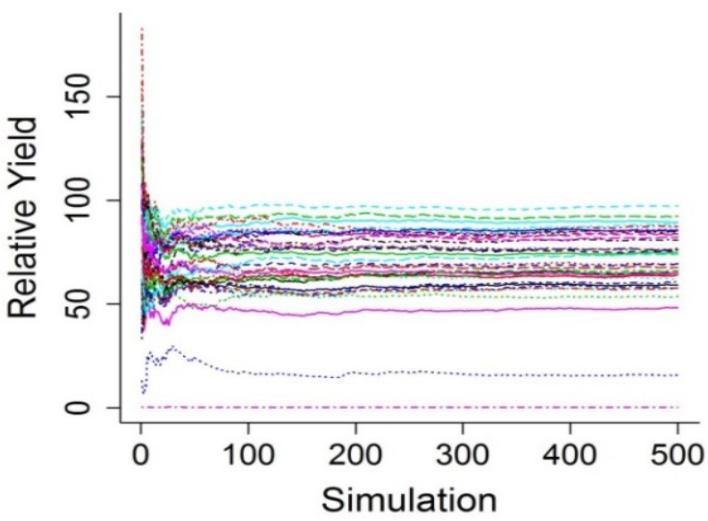
St. Thomas queen triggerfish: MSE performance results

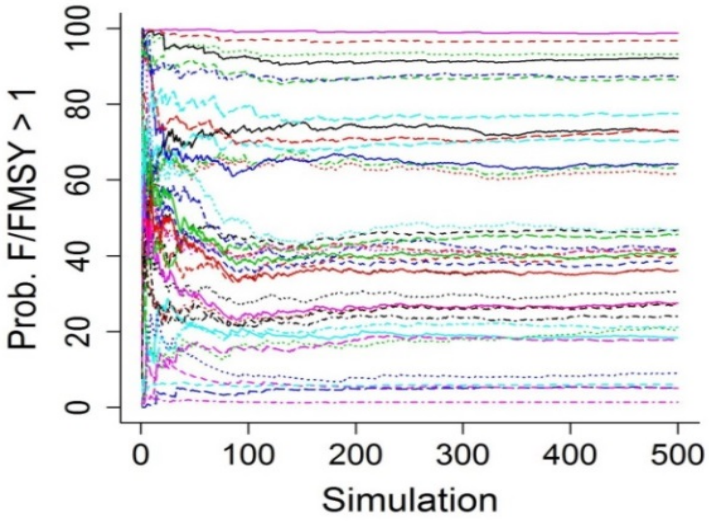
- Model convergence
- Tradeoff plots allow comparison of performance of feasible management procedures (MPs) between base and alternative OMs
  - Feasibility defined by data sufficiency
  - Sensitivity to assumptions made within OM components (stock, fleet, observation model inputs)
    - Life history
    - Fleet representativeness (selectivity)
    - Bias and quality of data inputs

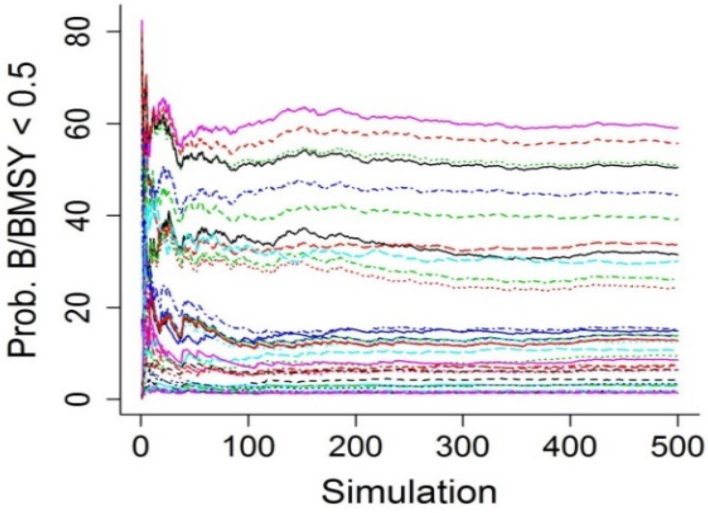
St. Thomas queen triggerfish: Model convergence

Assumes:

- Base stock, fleet, and subclass Scenarios
- n=500 sims, 250 reps







All MPs converged at threshold = 1%

Most MPs reached convergence by ~ 300 simulations

St. Thomas queen triggerfish: Tradeoffs in performance by MP

Assumes:

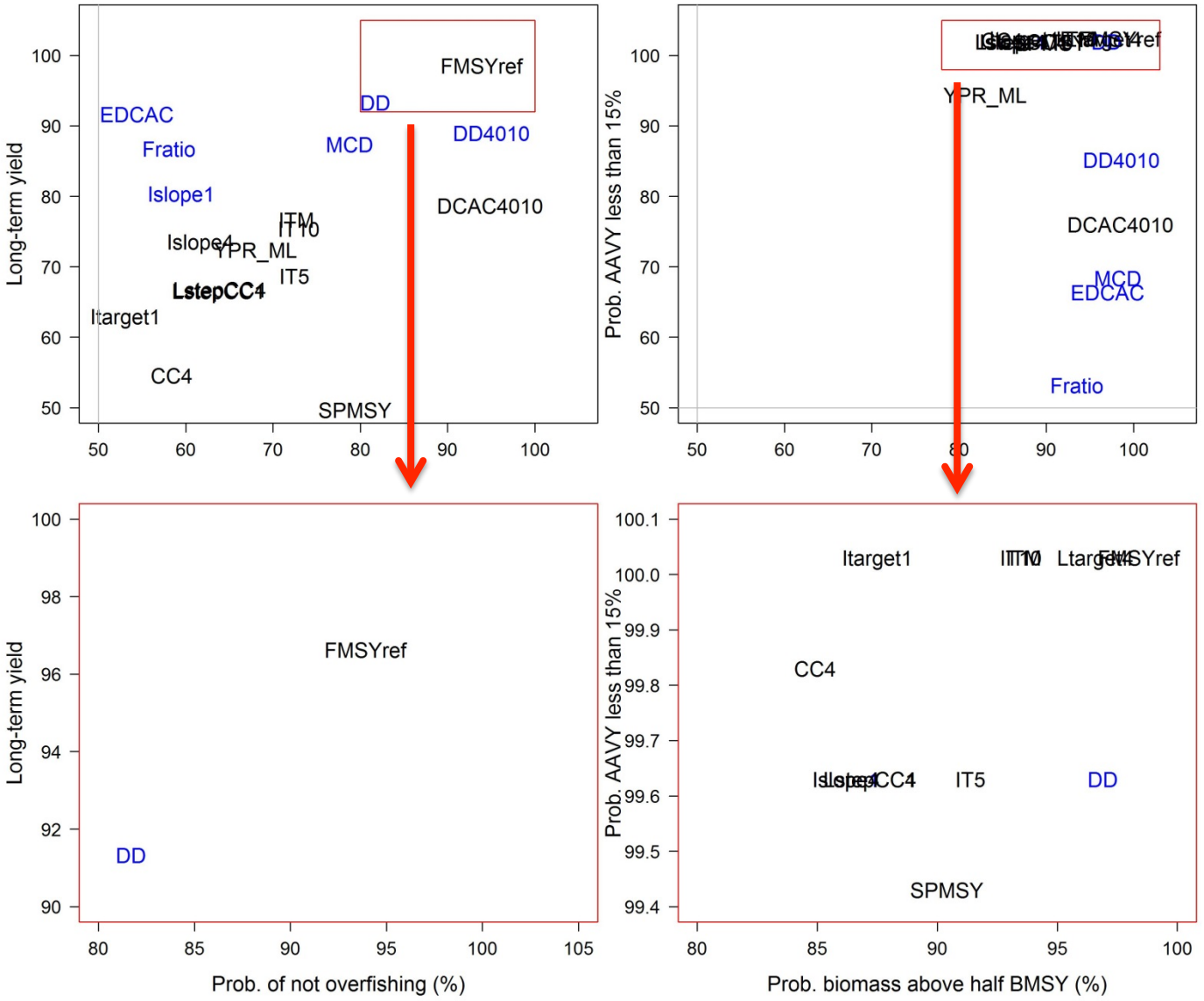
Base stock, fleet, and subclass scenarios

Long-term yield:

- The fraction of simulations achieving over 50% FMSY yield over the final 10 years of the projection

FMSYref:

- Assumes perfect information



St. Thomas queen triggerfish: MSE performance

Base Stock/Fleet					Alt Fleet					Alt Stock/Fleet				
15% LH, high dome selex					15% LH, Moderate dome selex					5% LH, Moderate dome selex				
MP	PNOF	B50	LTY	AAVY	MP	PNOF	B50	LTY	AAVY	MP	PNOF	B50	LTY	AAVY
Reference MP														
FMSYref	93.9	98.4	96.2	100	FMSYref	93.5	98.3	99.6	100	FMSYref	93.6	97.5	99.7	100
MPs producing 6 highest long-term yields that meet AP criteria														
DD	81.7	96.9	90.9	99.6	DD	80.6	96.1	96.4	99.8	DD	88.1	96.3	97.4	99.2
EDCAC	54.4	97	89.3	64	EDCAC	52.8	97.1	94	60.8	DD4010	97.4	97.8	94.9	78.4
DD4010	95	98.6	86.6	82.8	DD4010	93.8	98.2	93.6	76.4	EDCAC	58.8	96.1	94.8	57.6
MCD	78.8	98.2	85	66	MCD	79.5	98.3	92.5	70.4	Fratio	59.2	91.2	92.1	53.8
Fratio	58.1	93.5	84.4	50.8	BK	59.3	91.4	90.5	55	MCD	84	97.4	91.6	68.8
Islope1	59.5	86.2	78	99.6	Fratio	59.2	92.3	90.5	56.2	BK	58.9	90.5	89.9	51
Other MPs producing lower long-term yields that meet AP criteria														
DCAC4010	94.9	98.5	76.3	73.6	DCAC4010	94.1	98.5	84.6	75	Islope1	59.7	82.9	84.3	99.6
ITM	72.7	93.6	74.3	100	Islope1	58	84.1	83.7	99.6	DCAC4010	96.7	97.8	82	76
IT10	73	93.5	73	100	ITM	71.7	93	78.5	100	Islope4	62.5	83	75.2	99.6
Islope4	61.7	86.2	71.2	99.6	Islope4	60.5	84.1	78.4	99.6	ITM	77.1	92	73.4	99.8
IT5	72.5	91.4	66.3	99.6	IT10	72.8	92.6	78	100	IT10	77.3	91.6	72.2	99.8
LstepCC4	63.9	87.2	64.4	99.6	IT5	73.1	90.5	74.7	99.8	LstepCC1	64.7	83.9	65.7	99.6
LstepCC1	63.8	87.2	64.2	99.6	LstepCC4	62.7	85	69.6	99.8	LstepCC4	64.9	84	63.9	99.6
Itarget1	53.1	87.5	60.6	100	LstepCC1	63	85.1	69.3	99.8	IT5	75.6	89.1	63.9	99.6
CC4	58.4	84.9	52.2	99.8	Itarget1	52.9	85.2	63.5	99.8	CC4	56.7	80.1	53.4	99.8
SPMSY	79.4	90.4	47.3	99.4	CC4	58.2	83.8	57.6	99.8	SPMSY	83.7	91.1	44.6	99.6
Ltarget4	91	96.6	9.1	100	SPMSY	80.1	90.9	49	99.8	Ltarget4	88.1	94	9	100
					Ltarget4	89.1	95.5	9.4	100					

Results for each OM sorted by long-term yield (LTY)

St. Thomas queen triggerfish: MSE performance

Base Stock/Fleet					Alt Observation				
15% LH, high dome selex					Imprecise, biased				
MP	PNOF	B50	LTY	AAVY	MP	PNOF	B50	LTY	AAVY
Reference MP									
FMSYref	93.9	98.4	96.2	100	FMSYref	93.8	98.5	96.6	100
MPs producing 6 highest long-term yields that meet AP criteria									
DD	81.7	96.9	90.9	99.6	DD	67.8	91.5	82.9	76.2
EDCAC	54.4	97	89.3	64	Islope1	63.9	84.9	63.8	97.4
DD4010	95	98.6	86.6	82.8	Islope4	65.7	85.1	60.9	98
MCD	78.8	98.2	85	66	ITM	69.5	89.1	56.4	99.8
Fratio	58.1	93.5	84.4	50.8	IT10	70.7	89.3	55.8	99.8
Islope1	59.5	86.2	78	99.6	LstepCC1	68.1	86.3	53.8	99.2
Other MPs producing lower long-term yields that meet AP criteria									
DCAC4010	94.9	98.5	76.3	73.6	LstepCC4	68.1	86.3	53.2	99.6
ITM	72.7	93.6	74.3	100	IT5	72.3	88.5	51.3	99.6
IT10	73	93.5	73	100	SPMSY	79.7	89.7	40.3	99.2
Islope4	61.7	86.2	71.2	99.6	Itarget1	62.9	84.8	35.5	78.2
IT5	72.5	91.4	66.3	99.6	CC4	60	80.3	33.1	91.4
LstepCC4	63.9	87.2	64.4	99.6	Ltarget4	78.5	90.4	19.9	77.4
LstepCC1	63.8	87.2	64.2	99.6					
Itarget1	53.1	87.5	60.6	100					
CC4	58.4	84.9	52.2	99.8					
SPMSY	79.4	90.4	47.3	99.4					
Ltarget4	91	96.6	9.1	100					

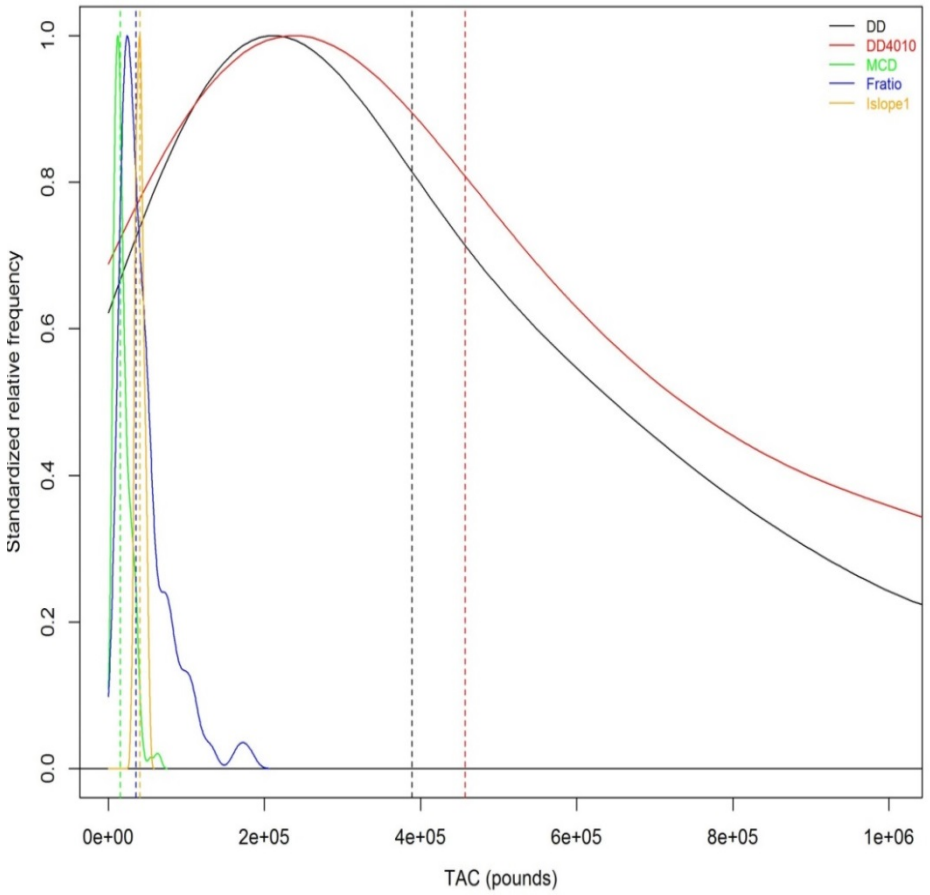
Results for each OM sorted by long-term yield (LTY)

St. Thomas queen triggerfish: Catch recommendations

- **MPs shown** for catch recommendations which:
  - Met performance criteria specified by SEDAR 46 DW/AW Panel
  - Produced the highest relative long-term yields in the MSE relative to the FMSYref

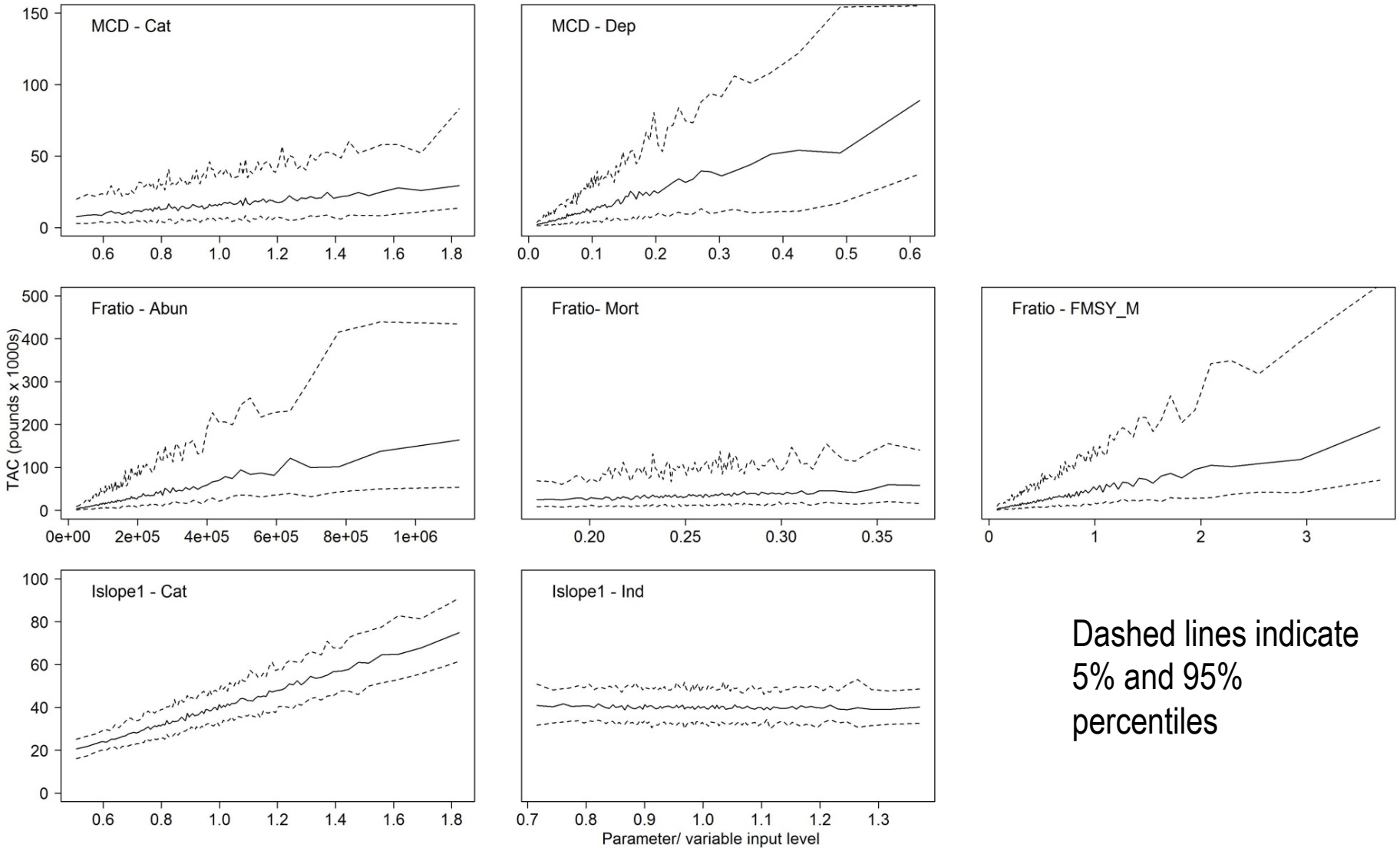
St. Thomas queen triggerfish: Catch recommendations

	Summary statistics (TACs, in pounds)				
MP	Min	25th Percentile	Median	75th Percentile	Max
MPs producing 6 highest long-term yields that meet AP criteria					
DD	22,311	222,507	580,772	1,185,747	9,990,730
DD4010	15,025	189,053	444,872	982,765	6,774,825
Islope1	28,381	35,944	40,033	43,179	53,618
Fratio	7,648	23,170	33,454	56,018	167,219
MCD	3,403	10,893	16,844	25,157	64,207
Other MPs that meet AP criteria					
CC4	26,371	33,963	36,986	39,559	50,565
Itarget1	23,978	31,256	33,912	36,315	46,302
Islope4	20,571	28,092	30,520	32,957	39,667
SPMSY	1,196	13,344	23,927	33,598	56,094



Dashed lines indicate median value for each MP

St. Thomas queen triggerfish: Real world catch sensitivity

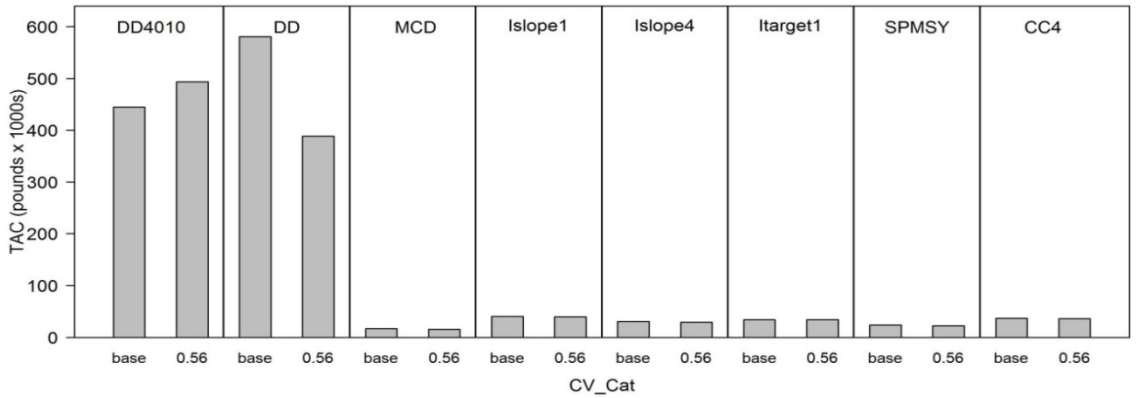


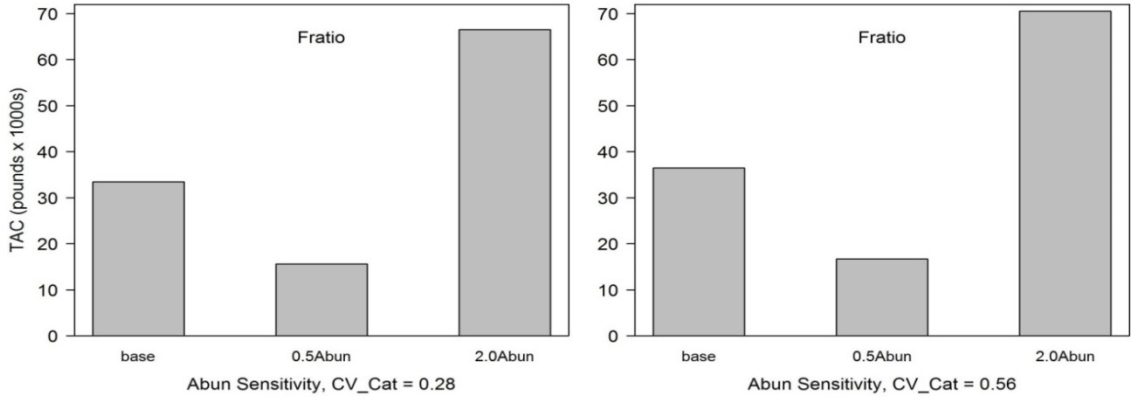
Dashed lines indicate 5% and 95% percentiles

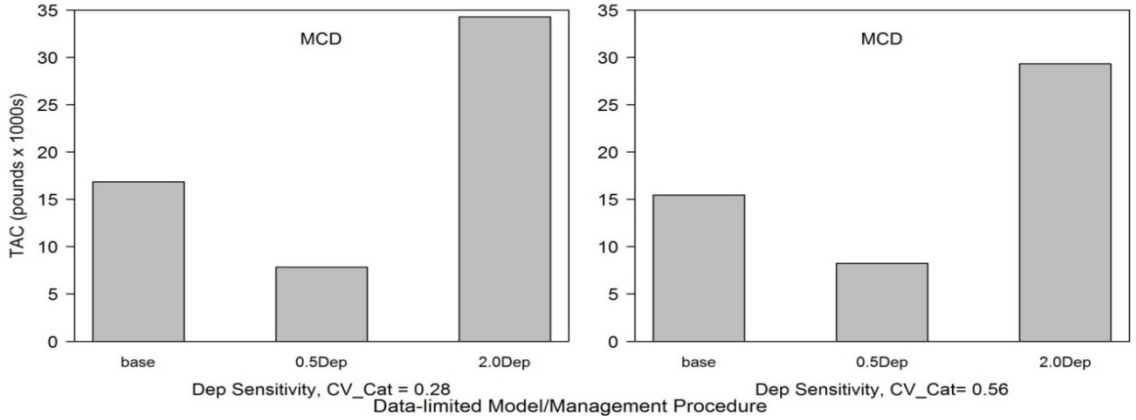
St. Thomas queen triggerfish: Catch sensitivity (cont'd)

Sensitivities:

- CV_Catch = 0.28
  - 2 x CV_Catch (0.56)
- Depletion (0.125)
  - 2 X Dep
  - 0.5 x Dep
- Abundance (229,008)
  - 2 x Abun
  - 0.5 x Abun



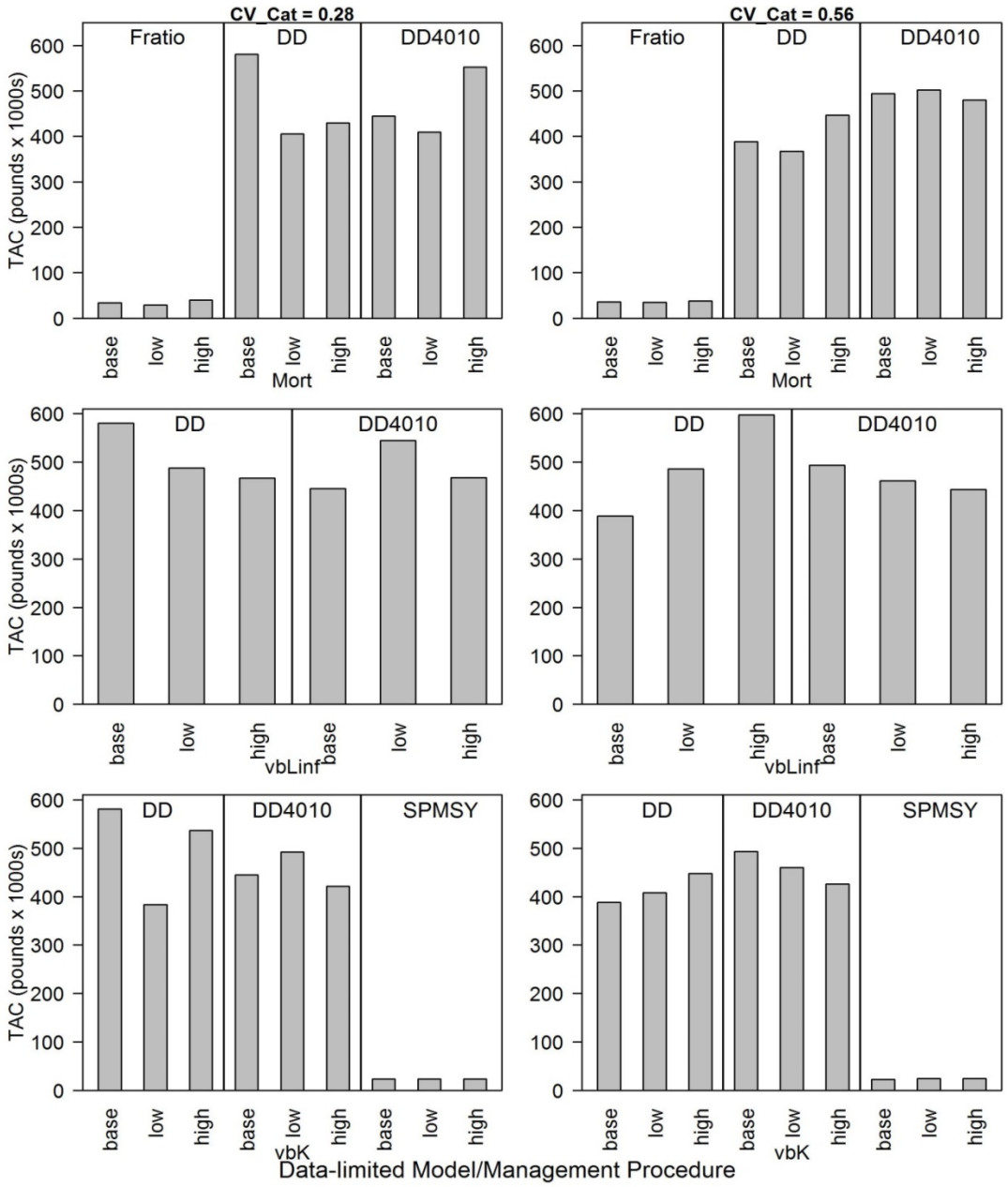




St. Thomas queen triggerfish: Catch sensitivity (cont'd)

Sensitivities:

- CV_Catch = 0.28
  - 2 x CV_Catch (0.56)
- LH (low, base, high)
  - Mort (0.22, 0.26, 0.30)
  - vbLinf (514, 605, 696)
  - vbK (0.18, 0.22, 0.25)



St. Thomas queen triggerfish: MP comparison guidance

Considerations important in selecting between MPs:

- Performance metrics (PNOF, B50, LTY, AAVY) by method type:
  - Abundance-based
  - Depletion-based
  - Data moderate
  - Index-based
  - Catch-based
- Life history inputs (spatial relevance, confidence in estimates)
- Data inputs (bias in catch, selectivity, index of abundance, fleet representativeness)

St. Thomas queen triggerfish: Guidance table

Considerations:

- Performance metrics

Parameter	Abun-based	Dep-based	Data-moderate		Index-based			Catch-based	
	Fratio	MCD	DD	DD4010	Islope1	Islope4	Itarget1	SPMSY	CC4
PNOF	58.1	78.8	81.7	95	59.5	61.7	53.1	79.4	58.4
B50	93.5	98.2	96.9	98.6	86.2	86.2	87.5	90.4	84.9
LTY	84.4	85	90.9	86.6	78	71.2	60.6	47.3	52.2
AAVY	50.8	66	99.6	82.8	99.6	99.6	100	99.4	99.8
Mort	Known, Constant across age		Known, constant across age						
AM			Life history characterizations reflective of STT					Life history characterizations reflective of STT	
vbt0									
vbK									
vbLinf									
wla									
wlb									
MaxAge			Age characterizations reflective of STT					Age characterizations reflective of STT	
Cat		Known, informative of historical removals							
FMSY_M	Known								
Ind			Fishery dependent representative of population						
Dep		Known, estimated from TIP samples and life history							
Abun	Known, estimated from current catch and F								

St. Thomas queen triggerfish: Guidance table

Considerations:

- LH from outside region, uncertainty in MaxAge

Parameter	Abun-based	Dep-based	Data-moderate		Index-based			Catch-based	
	Fratio	MCD	DD	DD4010	Islope1	Islope4	Itarget1	SPMSY	CC4
PNOF	58.1	78.8	81.7	95	59.5	61.7	53.1	79.4	58.4
B50	93.5	98.2	96.9	98.6	86.2	86.2	87.5	90.4	84.9
LTY	84.4	85	90.9	86.6	78	71.2	60.6	47.3	52.2
AAVY	50.8	66	99.6	82.8	99.6	99.6	100	99.4	99.8
Mort	Known, Constant across age		Known, constant across age						
AM			Life history characterizations reflective of STT					Life history characterizations reflective of STT	
vbt0									
vbK									
vbLinf									
wla									
wlb									
MaxAge			Age characterizations reflective of STT					Age characterizations reflective of STT	
Cat		Known, informative of historical removals							
FMSY_M	Known								
Ind			Fishery dependent representative of population						
Dep		Known, estimated from TIP samples and life history							
Abun	Known, estimated from current catch and F								

St. Thomas queen triggerfish: Guidance table

Considerations:

- Underreporting of catch & inconsistencies
- Representativeness of fleet: index of abundance

Parameter	Abun-based	Dep-based	Data-moderate		Index-based			Catch-based	
	Fratio	MCD	DD	DD4010	Islope1	Islope4	Itarget1	SPMSY	CC4
PNOF	58.1	78.8	81.7	95	59.5	61.7	53.1	79.4	58.4
B50	93.5	98.2	96.9	98.6	86.2	86.2	87.5	90.4	84.9
LTY	84.4	85	90.9	86.6	78	71.2	60.6	47.3	52.2
AAVY	50.8	66	99.6	82.8	99.6	99.6	100	99.4	99.8
Mort	Known, Constant across age		Known, constant across age						
AM			Life history characterizations reflective of STT					Life history characterizations reflective of STT	
vbt0									
vbK									
vbLinf									
wla									
wlb									
MaxAge			Age characterizations reflective of STT					Age characterizations reflective of STT	
Cat		Known, informative of historical removals							
FMSY_M	Known								
Ind			Fishery dependent representative of population						
Dep		Known, estimated from TIP samples and life history							
Abun	Known, estimated from current catch and F								

St. Thomas queen triggerfish: Guidance table

Considerations:

- Highly uncertain estimates of depletion and current abundance

Parameter	Abun-based	Dep-based	Data-moderate		Index-based			Catch-based	
	Fratio	MCD	DD	DD4010	Islope1	Islope4	Itarget1	SPMSY	CC4
PNOF	58.1	78.8	81.7	95	59.5	61.7	53.1	79.4	58.4
B50	93.5	98.2	96.9	98.6	86.2	86.2	87.5	90.4	84.9
LTY	84.4	85	90.9	86.6	78	71.2	60.6	47.3	52.2
AAVY	50.8	66	99.6	82.8	99.6	99.6	100	99.4	99.8
Mort	Known, Constant across age		Known, constant across age						
AM			Life history characterizations reflective of STT					Life history characterizations reflective of STT	
vbt0									
vbK									
vbLinf									
wla									
wlb									
MaxAge			Age characterizations reflective of STT					Age characterizations reflective of STT	
Cat		Known, informative of historical removals							
FMSY_M	Known								
Ind			Fishery dependent representative of population						
Dep		Known, estimated from TIP samples and life history							
Abun	Known, estimated from current catch and F								

St. Thomas queen triggerfish: summary

- Tradeoffs between MPs highlight the importance of selecting performance criteria
- Considerable uncertainty present in data inputs for US Caribbean species highlights caution when selecting MPs for management advice

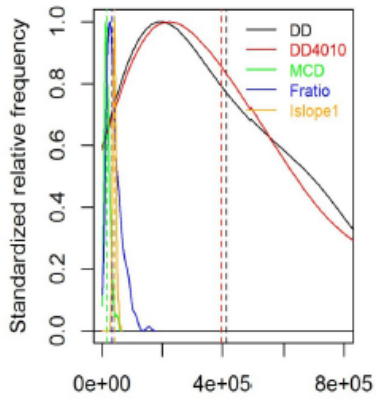
St. Thomas queen triggerfish assessment summary

Queen triggerfish (*Balistes vetula*) St. Thomas traps and pots

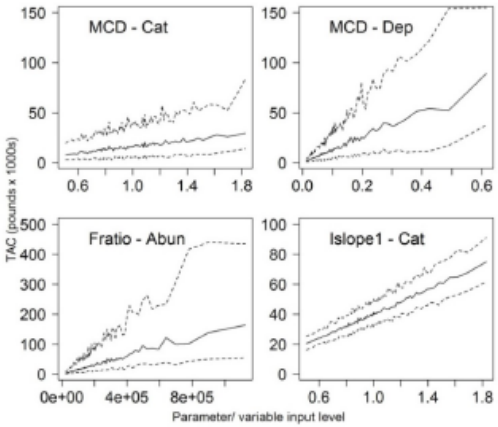
Management Evaluation Performance Results							
Ordered by PNOF				Ordered by LTY			
No	MP	PNOF	B50	No	MP	LTY	AAVY
1	DD4010	95.0	98.6	1	DD	90.9	99.6
2	DD	81.7	96.9	2	DD4010	86.6	82.8
3	SPMSY	79.4	90.4	3	MCD	85.0	66.0
4	MCD	78.8	98.2	4	Fratio	84.4	50.8
5	YPR_ML	65.0	78.0	5	Islope1	78.0	99.6
6	Islope4	61.7	86.2	6	Islope4	71.2	99.6
7	Islope1	59.5	86.2	7	YPR_ML	63.0	93.0
8	CC4	58.4	84.9	8	Itarget1	60.6	100.0
9	Fratio	58.1	93.5	9	CC4	52.2	99.8
10	Itarget1	53.1	87.5	10	SPMSY	47.3	99.4

PNOF = Prob. of not overfishing (%); **B50** = Prob. of B being above 0.5 BMSY (%); **LTY** = Relative long-term yield (fraction of simulations achieving > 50% FMSY yield over final 10 projection years); **AAVY** = fraction of simulations where average annual variability in yield < 15%

Distributions and Medians (dashed) for DLMtool Total Allowable Catch (TAC; pounds)



Subset of Catch Statistics Sensitivities:



DLMtool Catch Statistics (lbs)			
MP	Min	Median	Max
Highest long-term yields in MSE			
DD	22,311	580,772	9,990,730
DD4010	15,025	444,872	6,774,825
Islope1	28,381	40,033	53,618
Fratio	7,648	33,454	167,219
MCD	3,403	16,844	64,207
Other MPs that meet AP criteria			
CC4	26,371	36,986	50,565
Itarget1	23,978	33,912	46,302
Islope4	20,571	30,520	39,667
SPMSY	1,196	23,927	56,094

Mean length estimator (Huynh)	
YPR_ML (F0.1)	26,406

Catch Statistics (lbs)			
Catch	43,762	70,499	98,528
2014 Catch			44,107
2012–2014 Average Catch			44,235
1998-2014 Average Catch			63,367

Concerns and Caveats:

- **Method-specific assumptions** (e.g., constant M)
- **Sensitivity to data inputs**: life history parameters, depletion, and abundance
- **Data quality**: **life history parameters** derived from multiple regions outside Caribbean; underreporting of **catch** and inconsistency in recording triggerfish in data files; Appropriateness of fishery-dependent **index of abundance**, estimates of **stock depletion** and **current abundance**, appropriateness of TIP data in quantifying **length at first capture**

Considerations:

- Exclude MPs with catch recommendations near or exceeding maximum observed catches (DD/DD4010)
- Consider methods with high PNOF and LTY and weigh trade-offs in metrics

Results

- Species: spiny lobster
- Island: St. Thomas/St. John
- Gear: pots and traps

Content:

- MSE
  - Operating model
  - Convergence
  - Tradeoffs & performance
- Catch calculations
- Catch sensitivities
- Guidance

Photo from NOAA Photo Library (http://www.photolib.noaa.gov/).

St. Thomas spiny lobster: Operating model (OM)

Base OM:

- Stock (15% variability)
- Fleet (High Dome)
- Observation model (precise, unbiased)

Alternative OMs:

- Stock (5% variability)
- Fleet (Moderate Dome)
- Observation model (imprecise, biased)

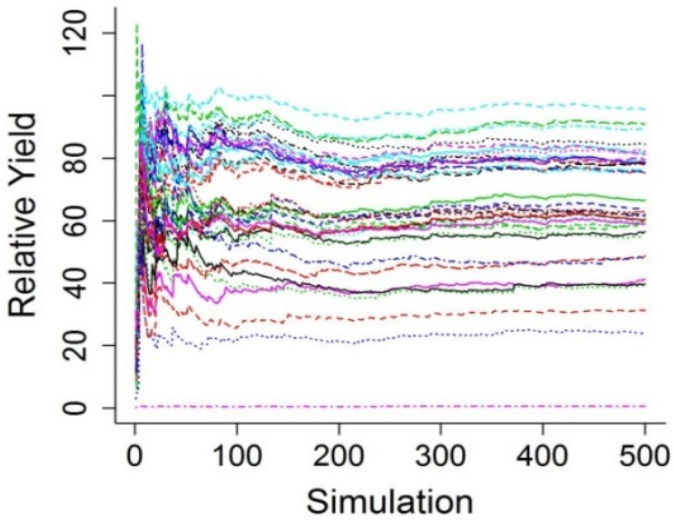
St. Thomas spiny lobster: MSE performance results

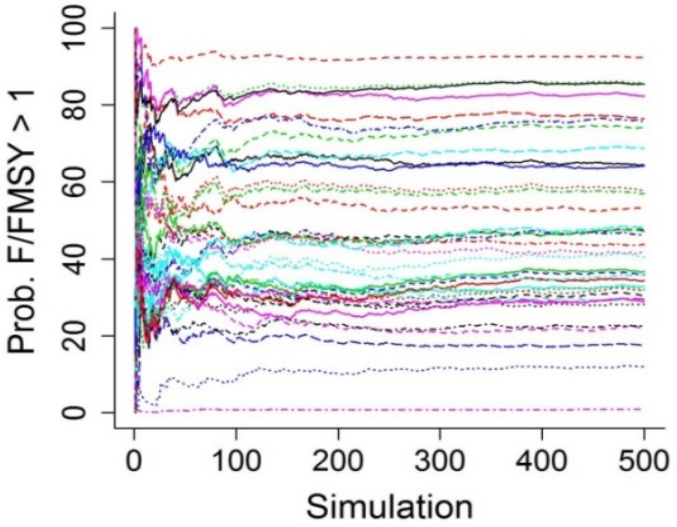
- Model convergence
- Tradeoff plots allow comparison of performance of feasible management procedures (MPs) between base and alternative OMs
  - Feasibility defined by sufficient data
  - Sensitivity to assumptions made within OMs (stock, fleet, observation)
    - Life history
    - Fleet
    - Bias and quality of data inputs

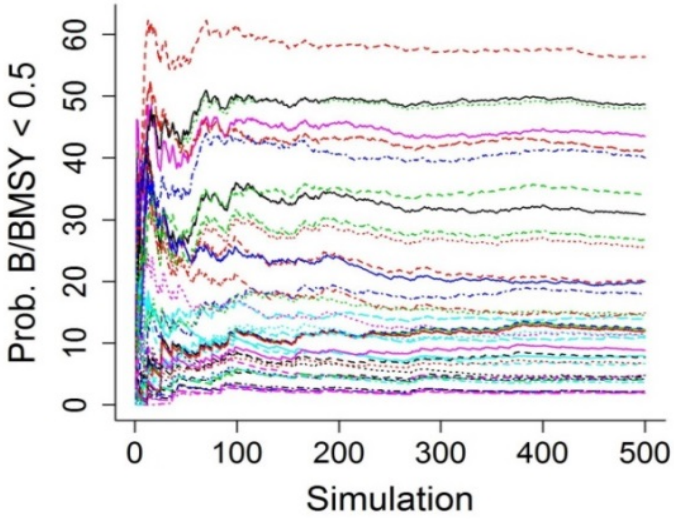
St. Thomas spiny lobster: Model convergence

Assumes:

- Base stock, fleet, and subclass Scenarios
- N=500 sims, 250 reps







All MPs converged at threshold = 1%

Most MPs reached convergence by ~ 300 simulations

St. Thomas spiny lobster: Tradeoffs in performance by MP

Assumes:

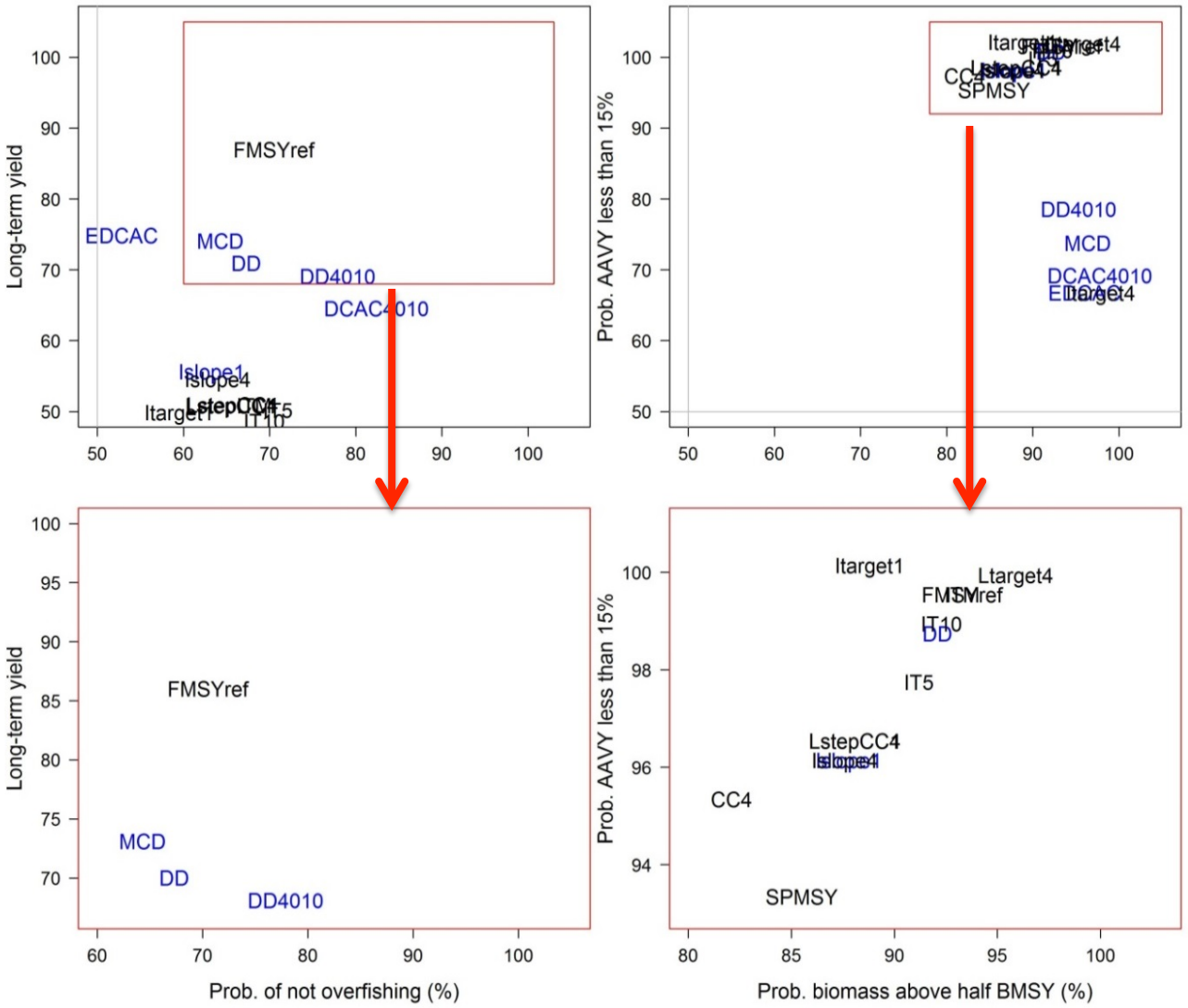
- Base stock, fleet, and subclass scenarios

Long-term yield:

- The fraction of simulations achieving over 50% FMSY yield over the final 10 years of the projection

FMSYref:

- Assumes perfect information



St. Thomas spiny lobster: MSE performance

Base Stock					Alt Stock/Fleet					Alt Fleet				
	15% LH, highly-dome					5% LH, moderate-dome					15% LH, moderate-dome			
MP	PNOF	B50	LTY	AAVY	MP	PNOF	B50	LTY	AAVY	MP	PNOF	B50	LTY	AAVY
Reference MP														
FMSYref	70.5	93.3	84.6	99.2	FMSYref	68.3	92.5	99.7	99.8	FMSYref	69.4	92.6	99.2	99.8
MPs producing 6 highest long-term yields that meet AP criteria														
EDCAC	52.8	96	72.5	64.4	EDCAC	54.9	95.4	85.3	65.8	EDCAC	54.4	95.5	85.4	69.6
MCD	64.3	96.4	71.7	71.4	Fratio	55.7	87.6	84.2	51.8	Fratio	56.1	87.3	84.9	54.4
DD	67.3	92.1	68.6	98.4	MCD	66.4	96	83.8	75.4	DD	67.7	90.8	83.7	98.6
DD4010	77.9	95.3	66.7	76.2	DD	67.8	91.3	83.5	98.6	MCD	66.5	96	83.5	77.4
DCAC4010	82.4	97.8	62.2	66.8	DD4010	78.1	95.2	81.9	79.6	DD4010	77.1	94.5	80.7	78
Islope1	63.3	87.8	53.3	95.8	DCAC4010	85.7	97.6	72.9	69.4	DCAC4010	85.2	97.5	74.2	69.8
Other MPs producing lower long-term yields that meet AP criteria														
Islope4	64	87.6	52.2	95.8	Islope1	67.4	87.2	66	97.2	Islope1	65.6	86.7	67.3	96.8
LstepCC4	65.7	88.1	48.6	96.2	Islope4	67.9	87	61.3	97.2	IT10	72.1	91.5	63	98.8
LstepCC1	65.6	88.1	48.5	96.2	ITM	70.8	92.2	60.8	99.6	Islope4	66.3	86.6	62.3	96.6
ITM	68.2	93.3	48.5	99.2	IT10	73.2	92.1	59.8	99	ITM	69.9	92	60.8	98.8
IT5	71	91.2	47.8	97.4	IT5	75.1	91	58.2	98.8	IT5	74	90.3	57.3	97.8
Itarget1	59.5	88.8	47.5	99.8	Itarget1	59.6	86.2	57.1	100	Itarget1	60.1	86.4	57.1	99.4
IT10	69.4	92.3	46.3	98.6	LstepCC4	69.6	87.6	55.5	97.4	LstepCC4	68.4	87	56.6	96.8
CC4	53.9	82.1	43.6	95	LstepCC1	69.5	87.6	54.9	97.4	LstepCC1	68.3	87	55.5	96.8
SPMSY	68.1	85.5	39.1	93	CC4	55	80.6	53	96.6	CC4	56.1	81.7	54.9	96.2
Ltarget4	88	95.9	12.2	99.6	SPMSY	67.9	83.5	47.2	92.2	SPMSY	67.5	84	46.2	92
Itarget4	99.1	97.9	0	64.4	Ltarget4	88	94.2	14.8	99.8	Ltarget4	88.2	94	14.2	100
					Itarget4	98.9	97.5	0	73.2	Itarget4	98.8	97.4	0.2	67.6

Results for each OM sorted by long-term yield (LTY)

St. Thomas spiny lobster: MSE performance

	Base Stock					Alt Observation			
	15% LH, highly-dome					Imprecise, biased			
MP	PNOF	B50	LTY	AAVY	MP	PNOF	B50	LTY	AAVY
Reference MP									
FMSYref	70.5	93.3	84.6	99.2	FMSYref	70.5	93.3	84.5	99.2
MPs producing 6 highest long-term yields that meet AP criteria									
EDCAC	52.8	96	72.5	64.4	DD	60.6	86	61.5	73.4
MCD	64.3	96.4	71.7	71.4	Islope1	65.1	86.1	44.7	94.2
DD	67.3	92.1	68.6	98.4	Islope4	65.1	86.1	43.5	94
DD4010	77.9	95.3	66.7	76.2	IT10	70.2	88.8	40.2	96.4
DCAC4010	82.4	97.8	62.2	66.8	ITM	68.8	89.3	40.2	96.8
Islope1	63.3	87.8	53.3	95.8	IT5	70.8	88.4	39.4	95
Other MPs producing lower long-term yields that meet AP criteria									
Islope4	64	87.6	52.2	95.8	LstepCC1	67.3	87	39.1	94.6
LstepCC4	65.7	88.1	48.6	96.2	LstepCC4	67.5	87.1	38.9	94.4
LstepCC1	65.6	88.1	48.5	96.2	SPMSY	73.3	86.5	35	91.8
ITM	68.2	93.3	48.5	99.2	CC4	61.6	79.5	24.6	87
IT5	71	91.2	47.8	97.4	Itarget1	69	85.8	22.4	78.8
Itarget1	59.5	88.8	47.5	99.8	Ltarget4	77.8	89.2	13.1	80.8
IT10	69.4	92.3	46.3	98.6					
CC4	53.9	82.1	43.6	95					
SPMSY	68.1	85.5	39.1	93					
Ltarget4	88	95.9	12.2	99.6					
Itarget4	99.1	97.9	0	64.4					

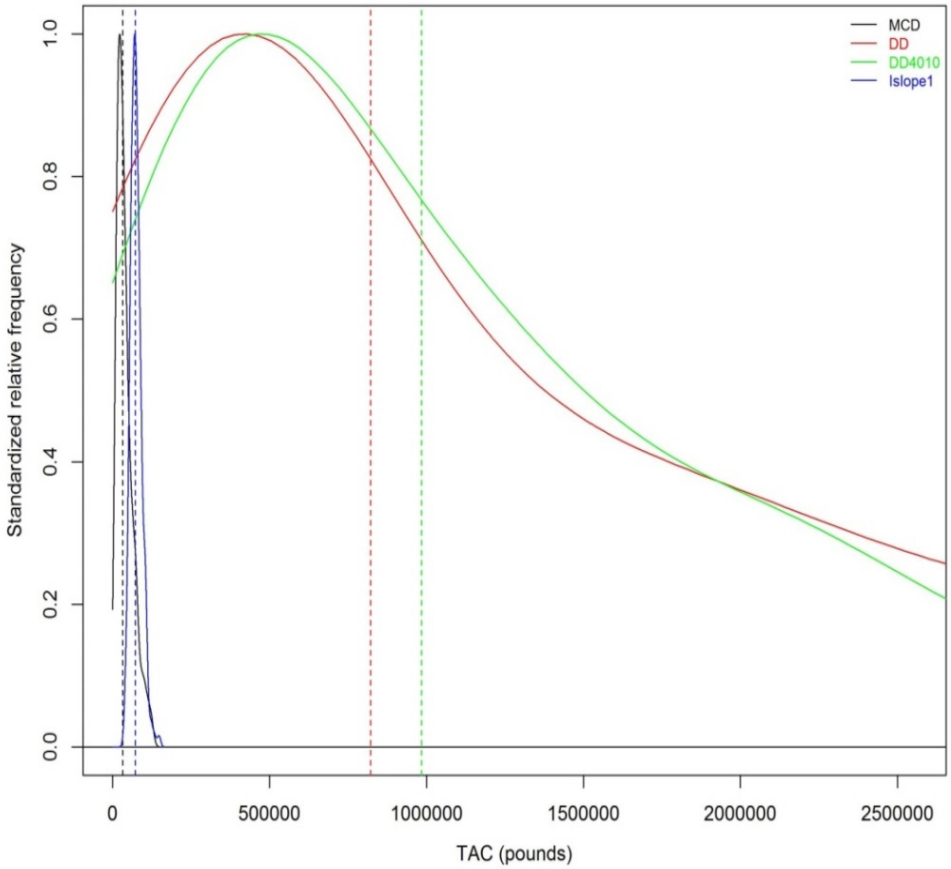
Results for each OM sorted by long-term yield (LTY)

St. Thomas spiny lobster: Catch recommendations

- **MPs shown** for catch recommendations which:
  - Met performance criteria specified by SEDAR 46 DW/AW Panel
  - Produced the highest relative long-term yields in the MSE relative to the FMSYref

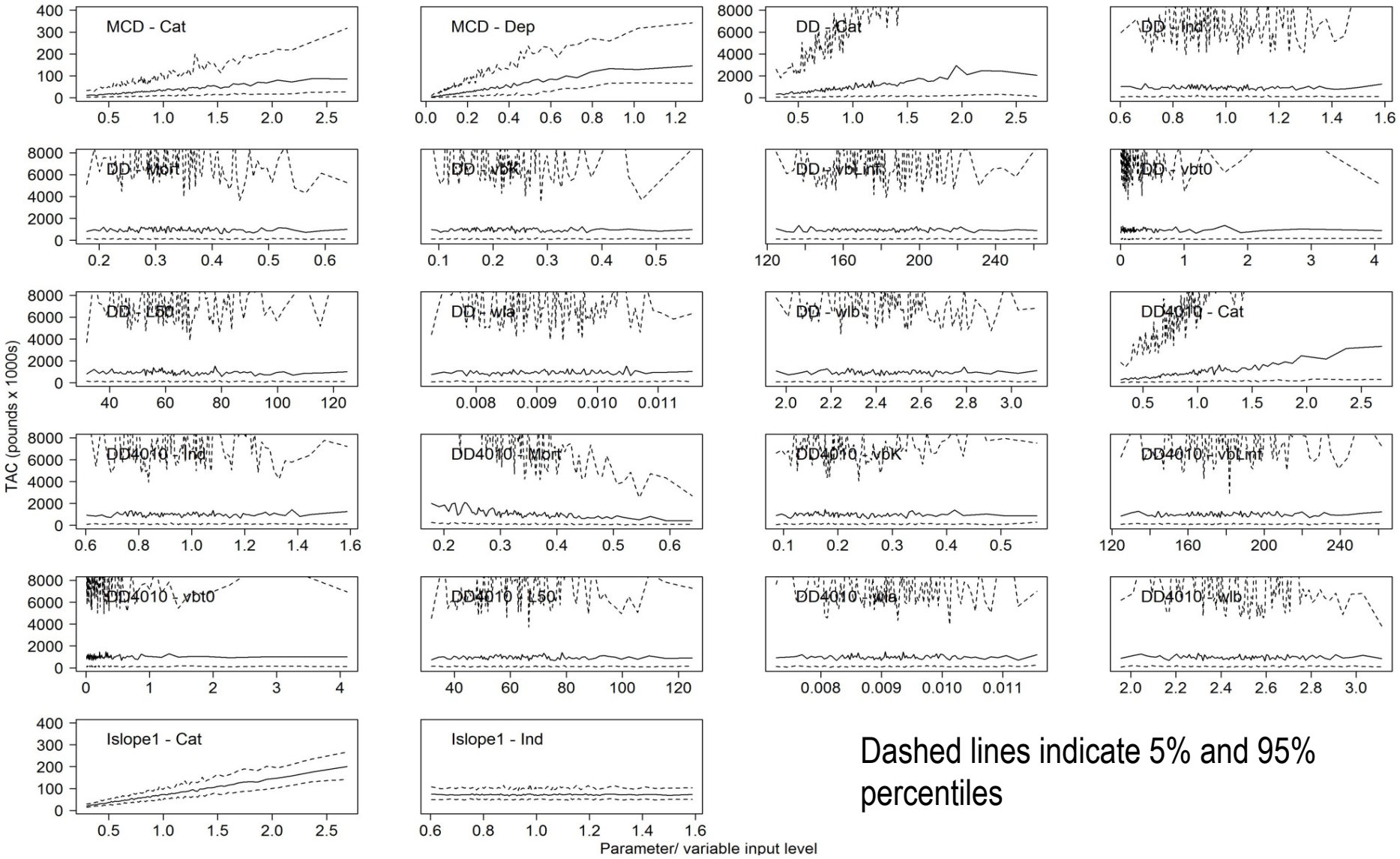
St. Thomas spiny lobster: Catch recommendations

	Summary statistics (TACs, in pounds)				
MP	Min	25th Percentile	Median	75th Percentile	Max
MPs producing 6 highest long-term yields that meet AP criteria					
DD4010	57,788	399,780	975,309	2,093,507	14,037,830
DD	42,888	420,632	869,317	1,959,024	18,334,000
Islope1	34,146	64,716	74,327	84,898	137,648
MCD	4,271	22,374	37,994	58,522	163,253
Other MPs that meet AP criteria					
SPMSY	34,351	71,492	96,269	119,107	150,547
CC4	24,725	52,999	60,922	71,612	115,889
Itarget1	34,357	50,268	59,332	70,475	104,463
Islope4	30,786	45,473	52,064	60,951	89,433
Itarget4	17,124	31,270	35,017	41,316	63,534



Dashed lines indicate median value for each MP

St. Thomas spiny lobster: real world catch sensitivity

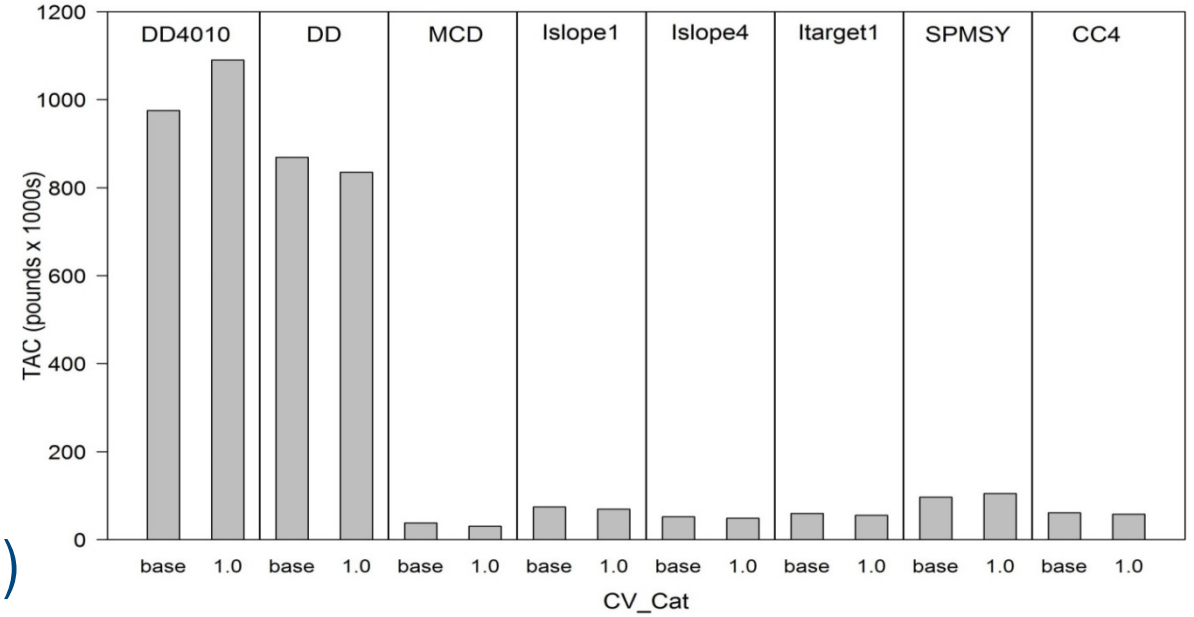


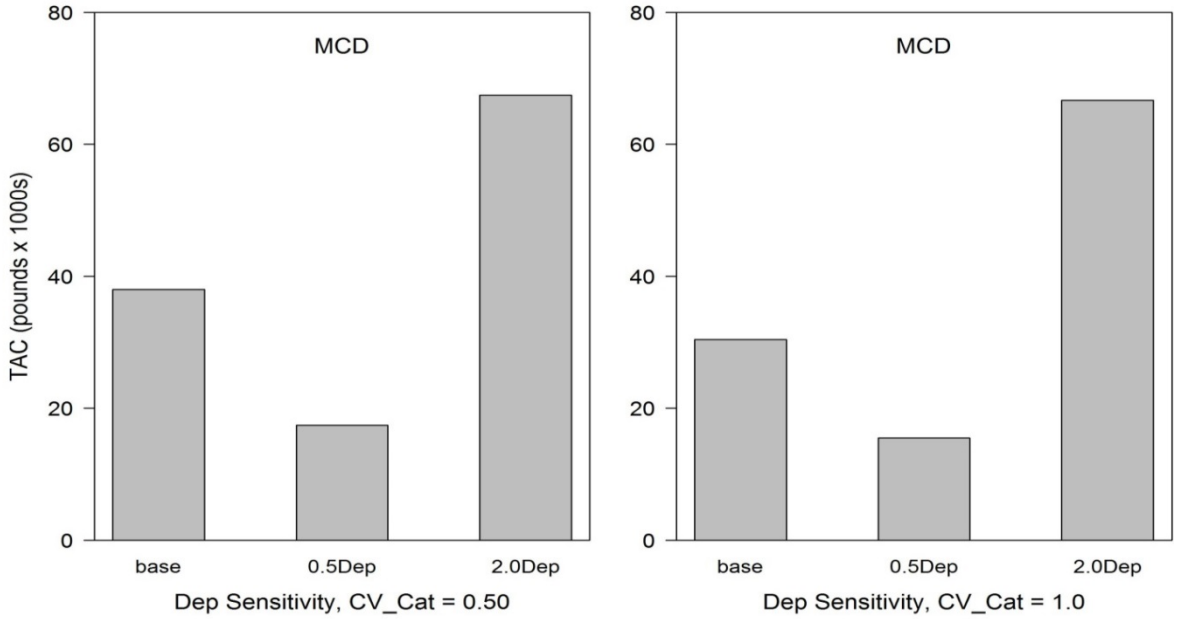
Dashed lines indicate 5% and 95% percentiles

St. Thomas spiny lobster: Catch sensitivity (cont'd)

Sensitivities:

- CV_Catch = 0.50
  - 2 x CV_Catch (1.0)
- Depletion (0.26)
  - 2 X Dep
  - 0.5 x Dep

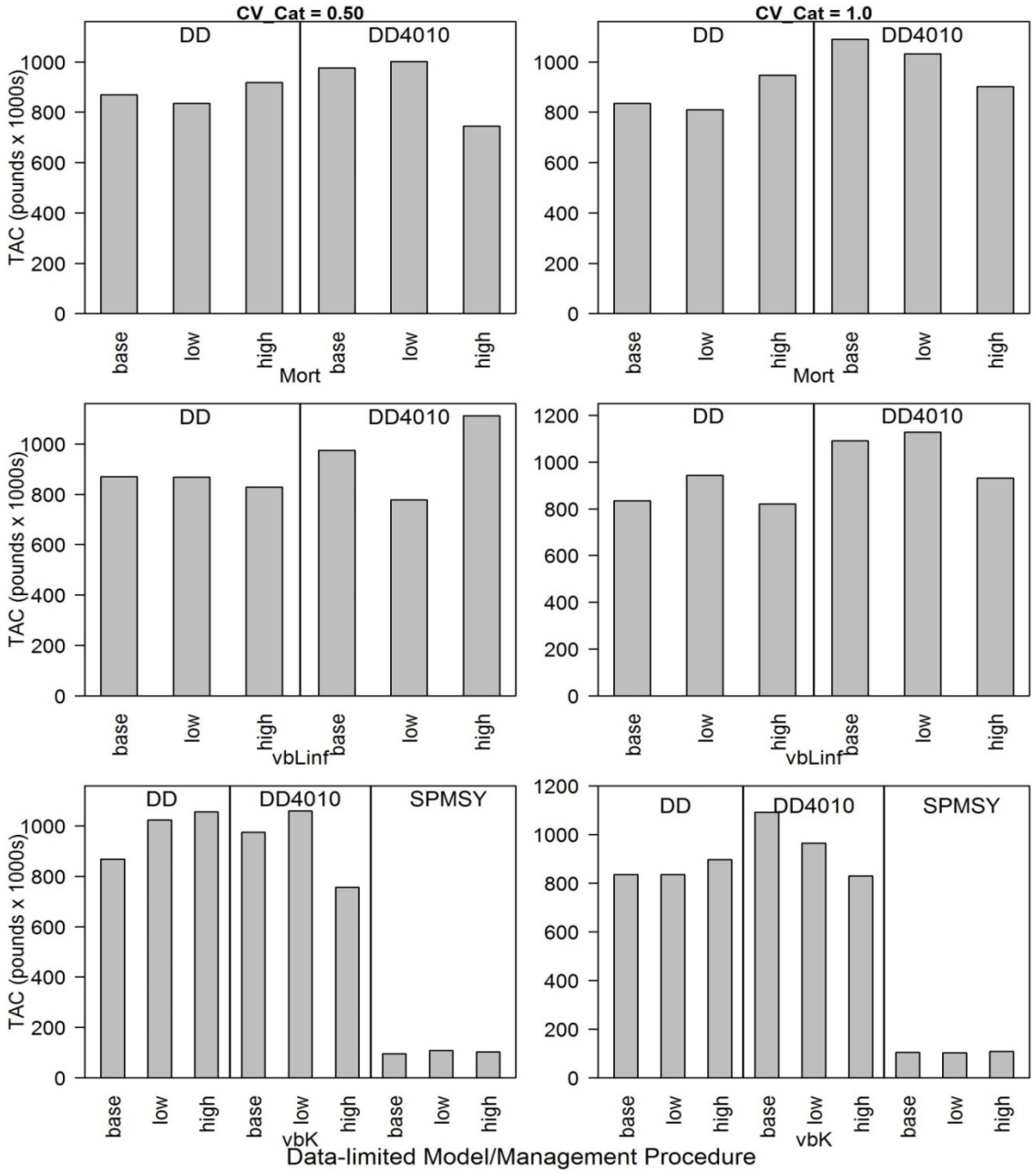




St. Thomas spiny lobster: Catch sensitivity (cont'd)

Sensitivities:

- CV_Catch = 0.50
  - 2 x CV_Catch (1.0)
- LH (low, base, high)
  - Mort (0.30, 0.35, 0.40)
  - vbLinf (155, 183, 210)
  - vbK (0.20, 0.24, 0.28)



St. Thomas spiny lobster: Guidance table for comparing MPs

Considerations important in selecting between MPs:

- Performance metrics (PNOF, B50, LTY, AAVY) by method type:
  - Abundance-based
  - Depletion-based
  - Data moderate
  - Index-based
  - Catch-based
- Life history inputs (spatial relevance, confidence in estimates)
- Data inputs (bias in catch, selectivity, index of abundance, fleet representativeness)

St. Thomas spiny lobster: Guidance table

Considerations:

- Performance metrics

Parameter	Dep-based	Data-moderate		Index-based				Catch-based	
	MCD	DD	DD4010	Islope1	Islope4	Itarget1	Itarget4	SPMSY	CC4
PNOF	64.3	67.3	77.9	63.3	64	59.5	99.1	68.1	53.9
B50	96.4	92.1	95.3	87.8	87.6	88.8	97.9	85.5	82.1
LTY	71.7	68.6	66.7	53.3	52.2	47.5	0	39.1	43.6
AAVY	71.4	98.4	76.2	95.8	95.8	99.8	64.4	93	95
Mort		Known, constant across age							
L50		Life history characterizations reflective of STT						Life history characterizations reflective of STT	
vbt0									
vbK									
vbLinf									
wla									
wlb									
MaxAge		Age characterizations reflective of STT						Age characterizations reflective of STT	
Cat	Known, informative of historical removals								
Ind		Fishery dependent representative of population abundance, dependent upon accurate effort reporting							
Dep	Known, estimated from TIP samples and life history								

St. Thomas spiny lobster: Guidance table

Considerations:

- Uncertainty in MaxAge and Mort

Parameter	Dep-based	Data-moderate		Index-based				Catch-based	
	MCD	DD	DD4010	Islope1	Islope4	Itarget1	Itarget4	SPMSY	CC4
PNOF	64.3	67.3	77.9	63.3	64	59.5	99.1	68.1	53.9
B50	96.4	92.1	95.3	87.8	87.6	88.8	97.9	85.5	82.1
LTY	71.7	68.6	66.7	53.3	52.2	47.5	0	39.1	43.6
AAVY	71.4	98.4	76.2	95.8	95.8	99.8	64.4	93	95
Mort		Known, constant across age							
L50		Life history characterizations reflective of STT						Life history characterizations reflective of STT	
vbt0									
vbK									
vbLinf									
wla									
wlb									
MaxAge		Age characterizations reflective of STT						Age characterizations reflective of STT	
Cat	Known, informative of historical removals								
Ind		Fishery dependent representative of population abundance, dependent upon accurate effort reporting							
Dep	Known, estimated from TIP samples and life history								

St. Thomas spiny lobster: Guidance table

Considerations:

- Underreporting of catch
- Representativeness of fleet: index of abundance

Parameter	Dep-based	Data-moderate		Index-based				Catch-based	
	MCD	DD	DD4010	Islope1	Islope4	Itarget1	Itarget4	SPMSY	CC4
PNOF	64.3	67.3	77.9	63.3	64	59.5	99.1	68.1	53.9
B50	96.4	92.1	95.3	87.8	87.6	88.8	97.9	85.5	82.1
LTY	71.7	68.6	66.7	53.3	52.2	47.5	0	39.1	43.6
AAVY	71.4	98.4	76.2	95.8	95.8	99.8	64.4	93	95
Mort		Known, constant across age							
L50		Life history characterizations reflective of STT						Life history characterizations reflective of STT	
vbt0									
vbK									
vbLinf									
wla									
wlb									
MaxAge		Age characterizations reflective of STT						Age characterizations reflective of STT	
Cat	Known, informative of historical removals								
Ind		Fishery dependent representative of population abundance, dependent upon accurate effort reporting							
Dep	Known, estimated from TIP samples and life history								

St. Thomas spiny lobster: Guidance table

Considerations:

- Highly uncertain estimates of depletion and current abundance

Parameter	Dep-based	Data-moderate		Index-based				Catch-based	
	MCD	DD	DD4010	Islope1	Islope4	Itarget1	Itarget4	SPMSY	CC4
PNOF	64.3	67.3	77.9	63.3	64	59.5	99.1	68.1	53.9
B50	96.4	92.1	95.3	87.8	87.6	88.8	97.9	85.5	82.1
LTY	71.7	68.6	66.7	53.3	52.2	47.5	0	39.1	43.6
AAVY	71.4	98.4	76.2	95.8	95.8	99.8	64.4	93	95
Mort		Known, constant across age							
L50		Life history characterizations reflective of STT						Life history characterizations reflective of STT	
vbt0									
vbK									
vbLinf									
wla									
wlb									
MaxAge		Age characterizations reflective of STT						Age characterizations reflective of STT	
Cat	Known, informative of historical removals								
Ind		Fishery dependent representative of population abundance, dependent upon accurate effort reporting							
Dep	Known, estimated from TIP samples and life history								

St. Thomas spiny lobster: summary

- Tradeoffs between MPs highlight the importance of selecting performance criteria
- Considerable uncertainty present in data inputs for US Caribbean species highlights caution when selecting MPs for management advice

St. Thomas spiny lobster assessment summary

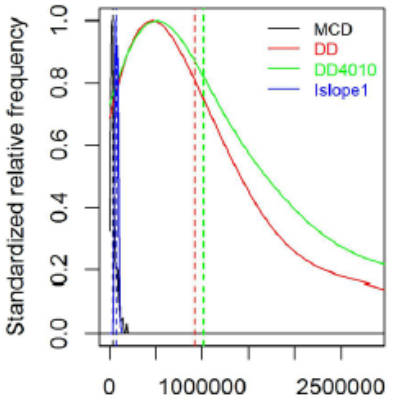
Spiny lobster (*Panulirus argus*) St. Thomas traps and pots

Management Evaluation Performance Results

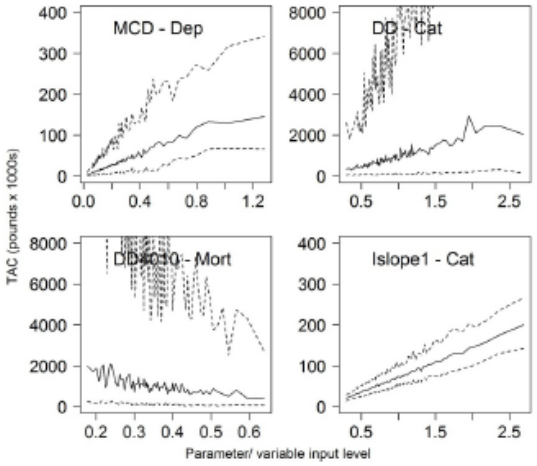
Ordered by PNOF				Ordered by LTY			
No	MP	PNOF	B50	No	MP	LTY	AAVY
1	Itarget4	99.1	97.9	1	MCD	71.7	71.4
2	DD4010	77.9	95.3	2	DD	68.6	98.4
3	SPMSY	68.1	85.5	3	DD4010	66.7	76.2
4	DD	67.3	92.1	4	Islope1	53.3	95.8
5	MCD	64.3	96.4	5	Islope4	52.2	95.8
6	Islope4	64.0	87.6	6	Itarget1	47.5	99.8
7	Islope1	63.3	87.8	7	CC4	43.6	95.0
8	Itarget1	59.5	88.8	8	SPMSY	39.1	93.0
9	CC4	53.9	82.1	9	Itarget4	0.0	64.4

PNOF = Prob. of not overfishing (%); **B50** = Prob. of B being above 0.5 BMSY (%); **LTY** = Relative long-term yield (fraction of simulations achieving > 50% FMSY yield over final 10 projection years); **AAVY** = fraction of simulations where average annual variability in yield < 15%

Distributions and Medians (dashed) for DLMtool Total Allowable Catch (TAC; pounds)



Subset of Catch Statistics Sensitivities:



DLMtool Catch Statistics (lbs)

MP	Min	Median	Max
Highest long-term yields in MSE			
DD4010	57,788	975,309	14,037,830
DD	42,888	869,317	18,334,000
Islope1	34,146	74,327	137,648
MCD	4,271	37,994	163,253
Other MPs that meet AP criteria			
SPMSY	34,351	96,269	150,547
CC4	24,725	60,922	115,889
Itarget1	34,357	59,332	104,463
Islope4	30,786	52,064	89,433
Itarget4	17,124	35,017	63,534

Mean length estimator (Huynh)
none meet performance criteria

Catch Statistics (lbs)			
Catch	6,742	75,991	136,027
2014 Catch			89,092
2012–2014 Average Catch			85,494
1975-2014 Average Catch			72,232

Concerns and Caveats:

- **Method-specific assumptions** (e.g., constant M)
- **Sensitivity to data inputs**: life history parameters, depletion, and abundance
- **Data quality**: uncertainty in **MaxAge and Mort**; underreporting of **catch** ; Appropriateness of fishery-dependent **index of abundance**, estimates of **stock depletion**, and appropriateness of TIP data in quantifying **length at first capture**

Considerations:

- Exclude MPs with catch recommendations near or exceeding maximum observed catches (DD/DD4010)
- Consider methods with high PNOF and LTY and weigh trade-offs in metrics

Results

- Species: spiny lobster
- Island: St. Croix
- Gear: diving

Content:

- MSE
  - Operating model
  - Convergence
  - Tradeoffs & performance
- Catch calculations
- Catch sensitivities
- Guidance

Photo from NOAA Photo Library (http://www.photolib.noaa.gov/).

St. Croix spiny lobster: Operating model (OM)

Base OM:

- Stock (15% variability)
- Fleet (High Dome)
- Observation model (precise, unbiased)

Alternative OMs:

- Stock (5% variability)
- Fleet (Moderate Dome)
- Observation model (imprecise, biased)

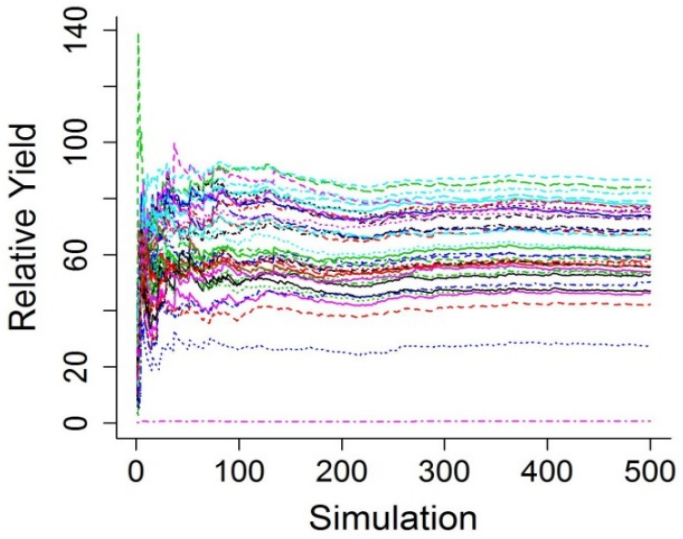
St. Croix spiny lobster: MSE performance results

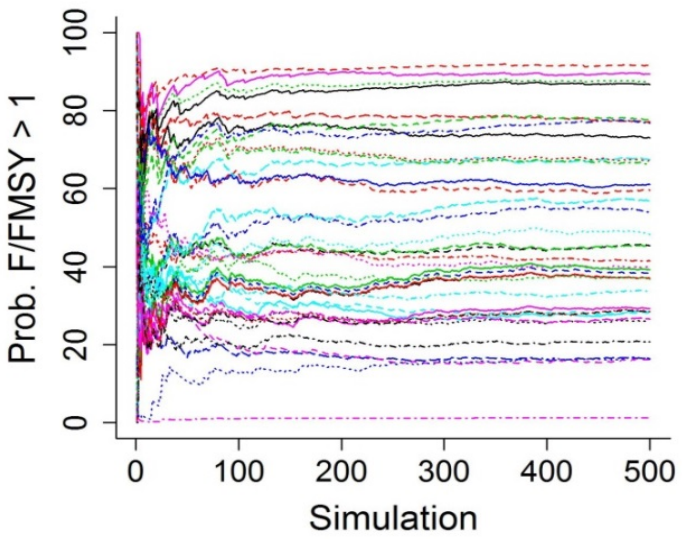
- Model convergence
- Tradeoff plots allow comparison of the performance of feasible management procedures (MPs) between base and alternative OMs
  - MP Feasibility defined by data sufficiency
  - Look at sensitivity to assumptions made within OMs (stock, fleet, observation model)
    - Life history
    - Fleet representativeness (selectivity)
    - Bias and quality of data inputs

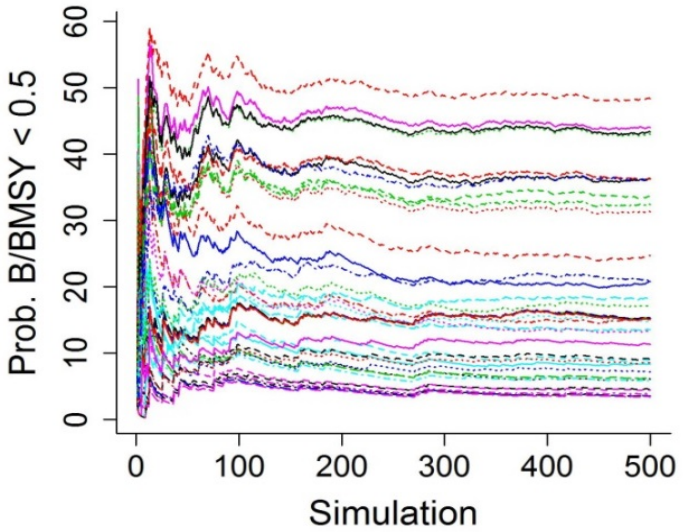
St. Croix spiny lobster: Model convergence

Assumes:

- Base stock, fleet, and subclass scenarios
- n=500 sims, 250 reps







All MPs converged at threshold = 1%

Most MPs reached convergence by ~ 300 simulations

St. Croix spiny lobster: Tradeoffs

Assumes:

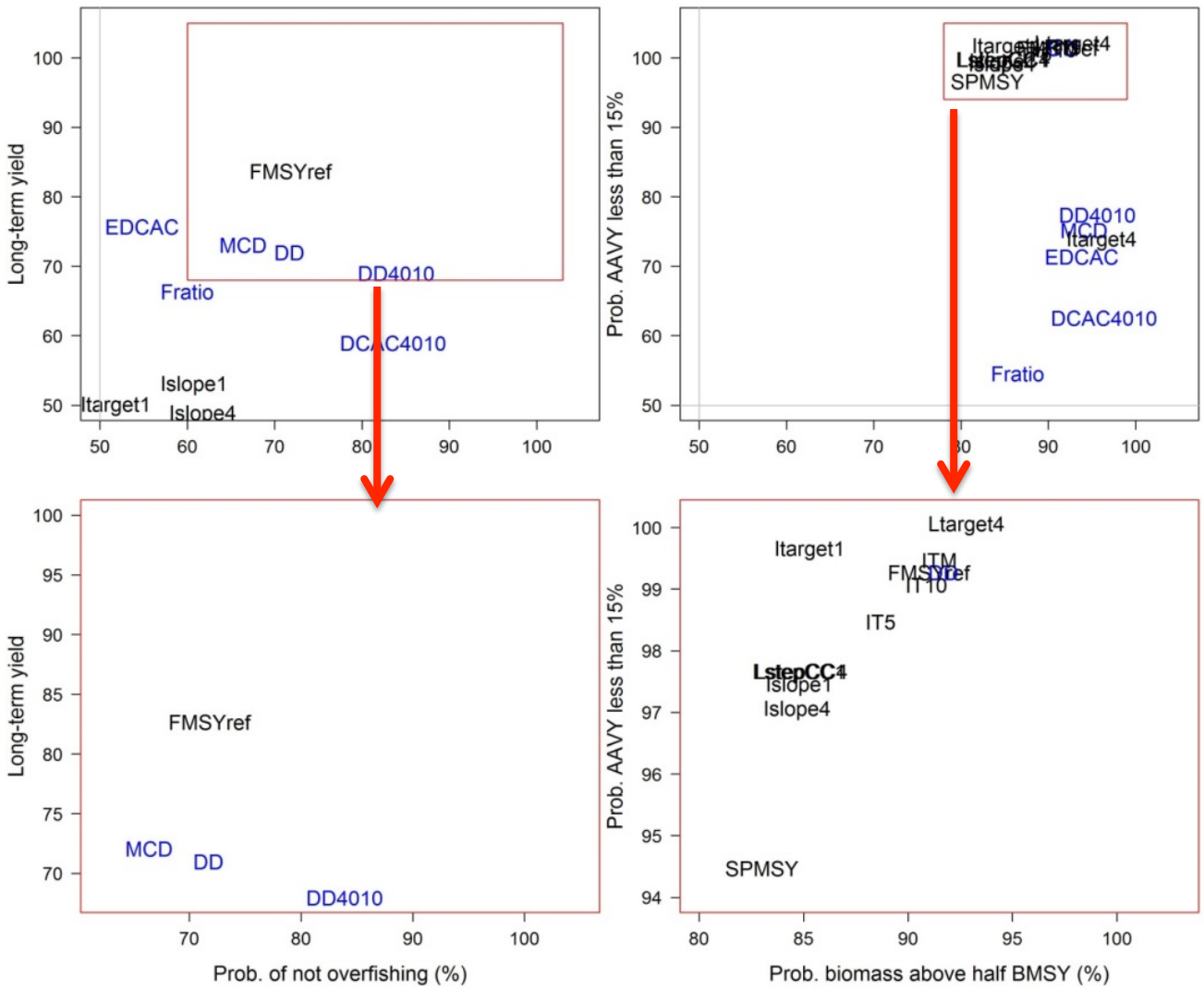
- Base stock, fleet, and subclass scenarios

Long-term yield:

- The fraction of simulations achieving over 50% FMSY yield over the final 10 years of the projection

FMSYref:

- Assumes perfect information



St. Croix spiny lobster: MSE performance

	Base Stock					Alt Stock/Fleet					Alt Fleet				
	15% LH, highly-dome					5% LH, moderate-dome					15% LH, moderate-dome				
	PNOF	B50	LTY	AAVY		PNOF	B50	LTY	AAVY		PNOF	B50	LTY	AAVY	
Reference MP															
FMSYref	71.8	91	81.3	99	FMSYref	69.8	90.3	99.1	99.8	FMSYref	69	92.6	99.2	99.4	
MPs producing 6 highest long-term yields that meet AP criteria															
EDCAC	54.8	93.8	73.3	69	DD	81.5	92.7	93.2	99.4	EDCAC	54.2	95.3	85.6	69.2	
MCD	66.4	94.1	70.7	72.8	MCD	67.6	94.4	93	75.4	MCD	66.3	96.1	84.8	77	
DD	71.7	91.7	69.6	99	EDCAC	55.3	93.7	91.7	66.6	Fratio	56.9	88	84.7	57	
DD4010	83.9	95.6	66.6	75	DD4010	93	96.3	85.8	77.4	DD	66.9	92	84.1	98.2	
Fratio	60	86.5	64	52.2	Fratio	56.9	85.7	84.6	53.8	DD4010	75.9	95.1	80	78.4	
DCAC4010	83.6	96.4	56.6	60.2	DCAC4010	85.6	96.6	78	59.4	DCAC4010	84.7	97.6	73.2	71.8	
Other MPs producing lower long-term yields that meet AP criteria															
Islope1	60.8	84.8	50.8	97.2	Islope1	58.6	81.3	69.7	97.4	Islope1	67.9	88.7	66.8	98.8	
Itarget1	51.8	85.3	47.8	99.4	Islope4	60.3	81.2	62	97.4	Islope4	68.7	88.6	63.3	98.6	
Islope4	61.8	84.7	46.6	96.8	LstepCC1	61.8	81.7	55.5	97.6	IT10	72.3	93.2	62	99.4	
LstepCC1	63	84.8	44	97.4	LstepCC4	61.9	81.6	55.2	97.6	ITM	69.9	93.4	61.8	99.6	
LstepCC4	63	84.9	44	97.4	IT5	73.6	87	53.6	99.4	CC4	54.6	84.6	59.7	97.8	
IT10	71.6	90.9	43.4	98.8	ITM	77.5	91.9	52.8	99.4	LstepCC4	70	88.7	59.4	98.6	
ITM	71.5	91.5	43.4	99.2	IT10	77.2	90.3	52.1	99.2	IT5	74.6	91.9	59.1	99.2	
SPMSY	63.3	83	40.7	94.2	SPMSY	63	80.6	49.3	93	LstepCC1	70	88.7	58.4	98.8	
IT5	70.8	88.7	40.2	98.2	Ltarget4	80.6	91.8	24.2	99.8	Itarget1	59.9	89	58.1	99.6	
Ltarget4	83.7	92.8	16.6	99.8	Itarget4	98.2	96.5	0	81.4	SPMSY	66.8	85	50.1	95	
Itarget4	98.7	96.1	0	71.6						Ltarget4	87	94.8	18.4	99.6	
										Itarget4	98.8	97.4	0	69.4	

Results for each OM sorted by long-term yield (LTY)

St. Croix spiny lobster: MSE performance

	Base Stock					Atl Observation			
	15% LH, highly-dome					Imprecise, biased			
	PNOF	B50	LTY	AAVY		PNOF	B50	LTY	AAVY
Reference MP									
FMSYref	71.8	91	81.3	99	FMSYref	71.8	91	81.2	99
MPs producing 6 highest long-term yields that meet AP criteria									
EDCAC	54.8	93.8	73.3	69	DD	63.9	86.7	62.6	76.2
MCD	66.4	94.1	70.7	72.8	Islope1	62.2	84.1	44.3	95.6
DD	71.7	91.7	69.6	99	Islope4	62.9	84	41.2	96
DD4010	83.9	95.6	66.6	75	LstepCC4	65.1	84.5	38.2	96.2
Fratio	60	86.5	64	52.2	ITM	70.5	88.9	38.2	98.4
DCAC4010	83.6	96.4	56.6	60.2	LstepCC1	65.2	84.6	37.5	96.2
Other MPs producing lower long-term yields that meet AP criteria									
Islope1	60.8	84.8	50.8	97.2	IT10	71.2	88.5	37.4	98
Itarget1	51.8	85.3	47.8	99.4	SPMSY	67.9	83.3	37.2	94.2
Islope4	61.8	84.7	46.6	96.8	IT5	70.2	87.4	36.3	97
LstepCC1	63	84.8	44	97.4	CC4	57	79.7	28.3	89.4
LstepCC4	63	84.9	44	97.4	Itarget1	63.1	84.6	25.7	79.2
IT10	71.6	90.9	43.4	98.8	Ltarget4	74.2	87.5	16.6	82.4
ITM	71.5	91.5	43.4	99.2					
SPMSY	63.3	83	40.7	94.2					
IT5	70.8	88.7	40.2	98.2					
Ltarget4	83.7	92.8	16.6	99.8					
Itarget4	98.7	96.1	0	71.6					

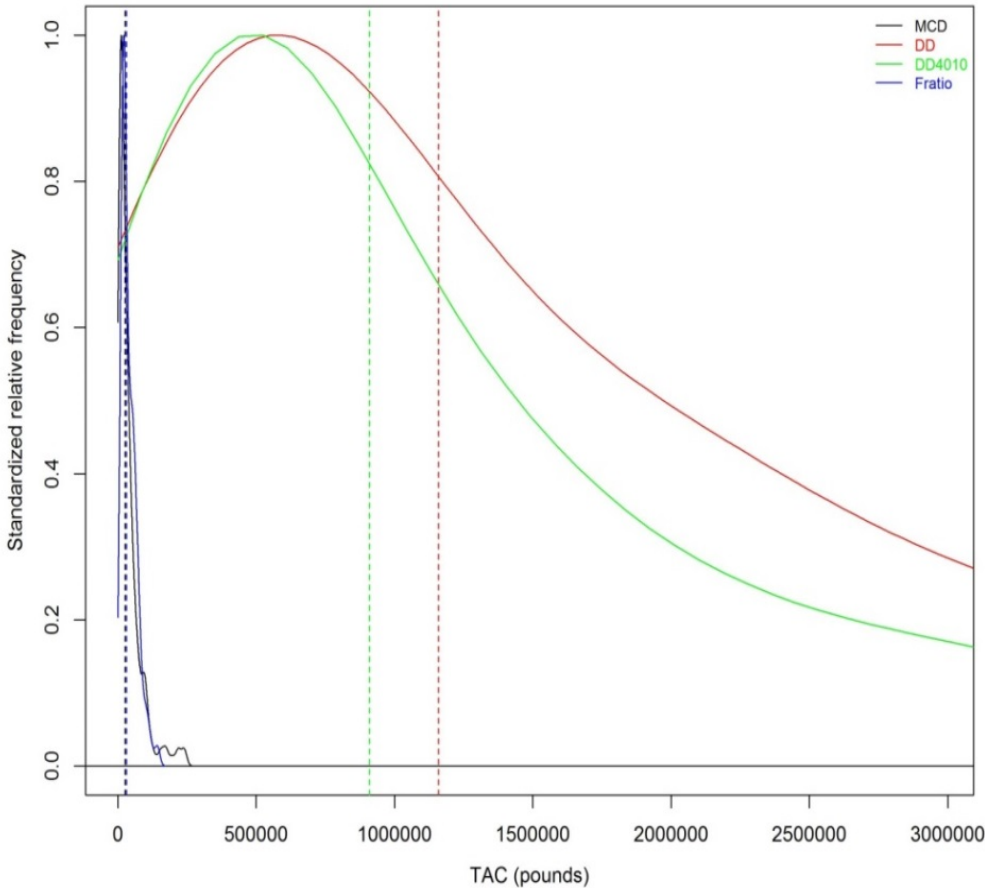
Results for each OM sorted by long-term yield (LTY)

St. Croix spiny lobster: Catch recommendations

- **MPs shown** for catch recommendations which:
  - Met performance criteria specified by SEDAR 46 DW/AW Panel
  - Produced the highest relative long-term yields in the MSE relative to the FMSYref

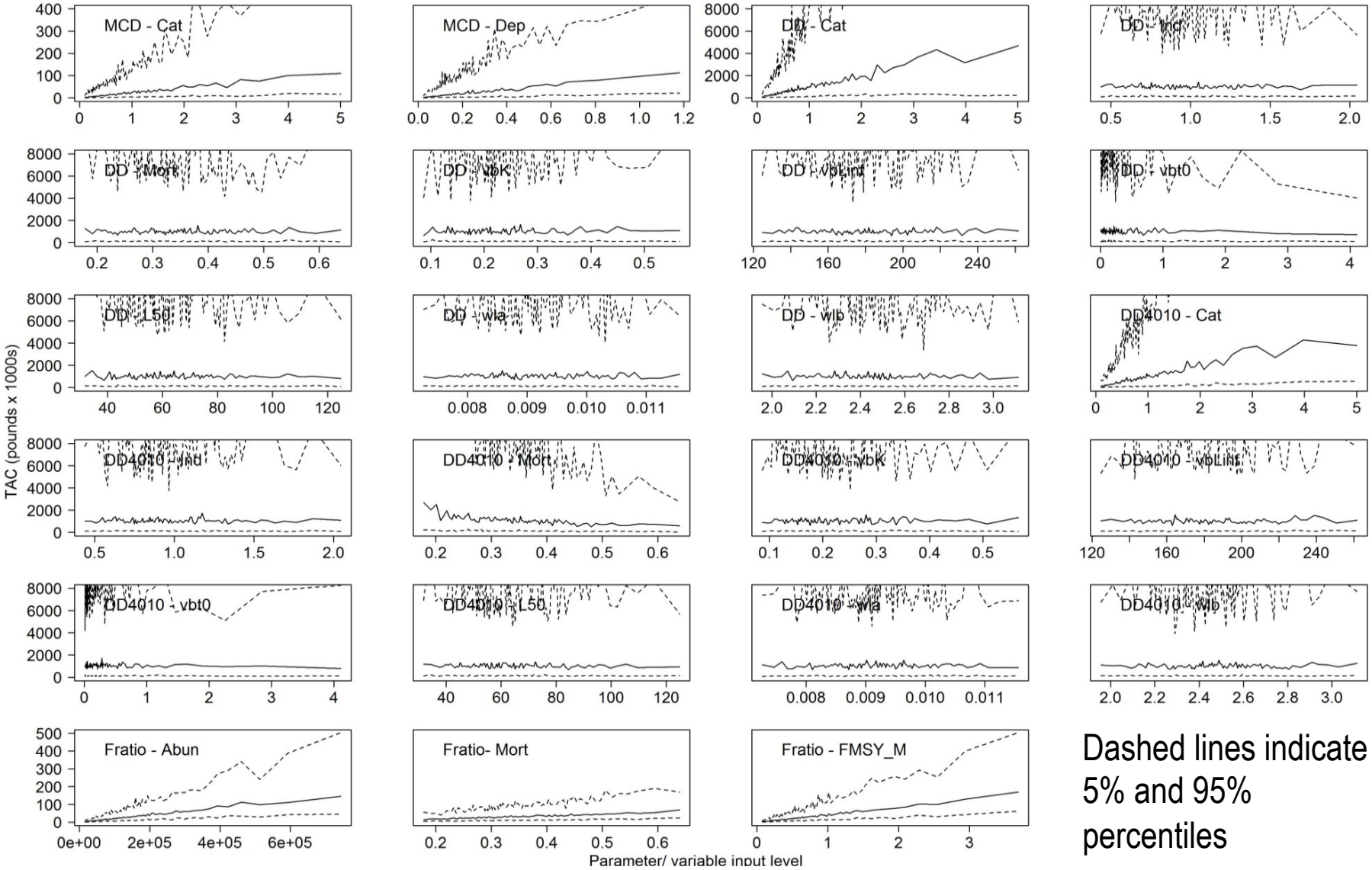
St. Croix spiny lobster: Catch recommendations

	Summary statistics (TACs, in pounds)				
MP	Min	25th Percentile	Median	75th Percentile	Max
MPs producing 6 highest long-term yields that meet AP criteria					
DD	38,692	439,183	1,047,478	3,168,908	17,270,400
DD4010	24,497	360,933	894,563	2,187,226	23,764,310
Fratio	4,637	19,680	29,015	51,439	144,193
MCD	1,242	11,324	21,247	45,899	247,998
Other MPs that meet AP criteria					
Islope1	15,102	39,873	55,563	75,385	178,913
Itarget1	13,800	39,022	50,164	68,139	162,328
Islope4	11,589	35,526	47,936	61,063	146,667
SPMSY	1,356	20,811	39,761	53,744	80,001
Itarget4	10,098	23,521	30,551	40,036	107,502



Dashed lines indicate median value for each MP

St. Croix spiny lobster: Real world catch sensitivity

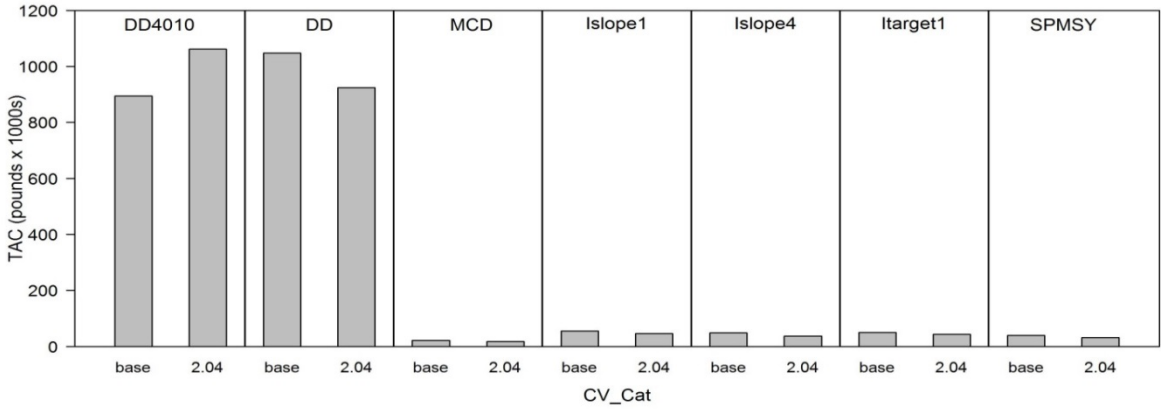


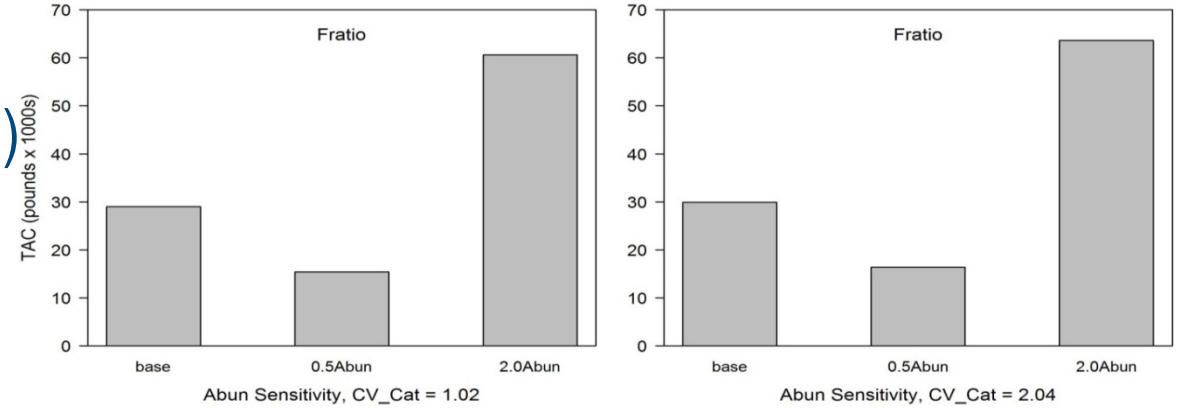
Dashed lines indicate 5% and 95% percentiles

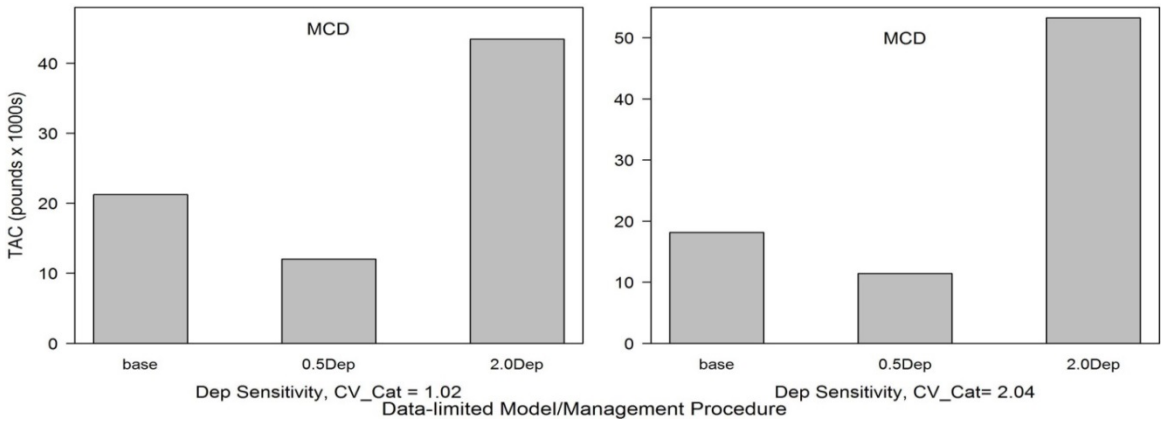
St. Croix spiny lobster: Catch sensitivity (cont'd)

Sensitivities:

- CV_Catch = 1.02
  - 2 x CV_Catch (2.04)
- Depletion (0.24)
  - 2 X Dep
  - 0.5 x Dep
- Abundance (151,166)
  - 2 x Abun
  - 0.5 x Abun



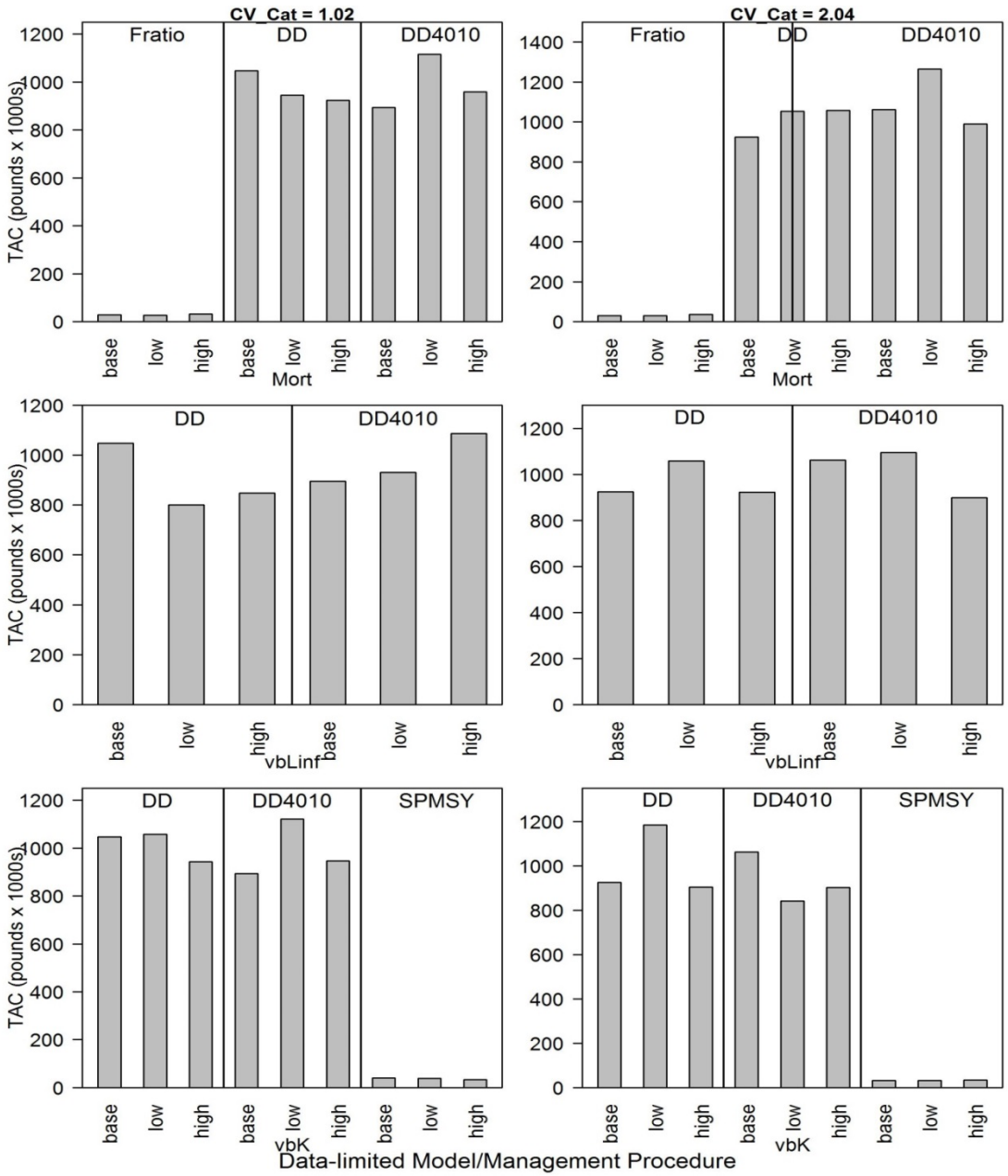




St. Croix spiny lobster: Catch sensitivity (cont'd)

Sensitivities:

- CV_Catch = 1.02
  - 2 x CV_Catch (2.04)
- LH (low, base, high)
  - Mort (0.30, 0.35, 0.40)
  - vbLinf (155, 183, 210)
  - vbK (0.20, 0.24, 0.28)



St. Croix spiny lobster: Guidance table for comparing MPs

Considerations important in selecting between MPs:

- Performance metrics (PNOF, B50, LTY, AAVY) by method type:
  - Abundance-based
  - Depletion-based
  - Data moderate
  - Index-based
  - Catch-based
- Life history inputs (e.g., spatial relevance, confidence in estimates)
- Data inputs (bias in catch, selectivity, index of abundance, fleet representativeness)

St. Croix spiny lobster: Guidance table

Considerations:

- Performance metrics

Parameter	Abun-based	Dep-based	Data-moderate		Index-based				Catch-based
	Fratio	MCD	DD	DD4010	Islope1	Islope4	Itarget1	Itarget4	SPMSY
PNOF	60	66.4	71.7	83.9	60.8	61.8	51.8	98.7	63.3
B50	86.5	94.1	91.7	95.6	84.8	84.7	85.3	96.1	83
LTY	64	70.7	69.6	66.6	50.8	46.6	47.8	0	40.7
AAVY	52.2	72.8	99	75	97.2	96.8	99.4	71.6	94.2
Mort	Known, constant across age		Known, constant across age						
AM			Life history characterizations reflective of STX						Life history characterizations reflective of STX
vbt0									
vbK									
vbLinf									
wla									
wlb									
MaxAge			Age characterizations reflective of STX						Age characterizations reflective of STX
Cat		Known, informative of historical removals							
FMSY_M	Known								
Ind			Fishery dependent representative of population abundance, dependent upon accurate effort reporting						
Dep		Known, estimated from TIP samples and life history							
Abun	Known, estimated from current catch and F								

St. Croix spiny lobster: Guidance table

Considerations:

- Uncertainty in MaxAge and Mort

Parameter	Abun-based	Dep-based	Data-moderate		Index-based				Catch-based
	Fratio	MCD	DD	DD4010	Islope1	Islope4	Itarget1	Itarget4	SPMSY
PNOF	60	66.4	71.7	83.9	60.8	61.8	51.8	98.7	63.3
B50	86.5	94.1	91.7	95.6	84.8	84.7	85.3	96.1	83
LTY	64	70.7	69.6	66.6	50.8	46.6	47.8	0	40.7
AAVY	52.2	72.8	99	75	97.2	96.8	99.4	71.6	94.2
Mort	Known, constant across age		Known, constant across age						
AM			Life history characterizations reflective of STX						Life history characterizations reflective of STX
vbt0									
vbK									
vbLinf									
wla									
wlb									
MaxAge			Age characterizations reflective of STX						Age characterizations reflective of STX
Cat		Known, informative of historical removals							
FMSY_M	Known								
Ind			Fishery dependent representative of population abundance, dependent upon accurate effort reporting						
Dep		Known, estimated from TIP samples and life history							
Abun	Known, estimated from current catch and F								

St. Croix spiny lobster: Guidance table

Considerations:

- Underreporting of catch
- Representativeness of fleet: index of abundance

Parameter	Abun-based	Dep-based	Data-moderate		Index-based				Catch-based
	Fratio	MCD	DD	DD4010	Islope1	Islope4	Itarget1	Itarget4	SPMSY
PNOF	60	66.4	71.7	83.9	60.8	61.8	51.8	98.7	63.3
B50	86.5	94.1	91.7	95.6	84.8	84.7	85.3	96.1	83
LTY	64	70.7	69.6	66.6	50.8	46.6	47.8	0	40.7
AAVY	52.2	72.8	99	75	97.2	96.8	99.4	71.6	94.2
Mort	Known, constant across age		Known, constant across age						
AM			Life history characterizations reflective of STX						Life history characterizations reflective of STX
vbt0									
vbK									
vbLinf									
wla									
wlb									
MaxAge			Age characterizations reflective of STX						Age characterizations reflective of STX
Cat		Known, informative of historical removals							
FMSY_M	Known								
Ind			Fishery dependent representative of population abundance, dependent upon accurate effort reporting						
Dep		Known, estimated from TIP samples and life history							
Abun	Known, estimated from current catch and F								

St. Croix spiny lobster: Guidance table

Considerations:

- Highly uncertain estimates of depletion and current abundance

Parameter	Abun-based	Dep-based	Data-moderate		Index-based				Catch-based
	Fratio	MCD	DD	DD4010	Islope1	Islope4	Itarget1	Itarget4	SPMSY
PNOF	60	66.4	71.7	83.9	60.8	61.8	51.8	98.7	63.3
B50	86.5	94.1	91.7	95.6	84.8	84.7	85.3	96.1	83
LTY	64	70.7	69.6	66.6	50.8	46.6	47.8	0	40.7
AAVY	52.2	72.8	99	75	97.2	96.8	99.4	71.6	94.2
Mort	Known, constant across age		Known, constant across age						
AM			Life history characterizations reflective of STX						Life history characterizations reflective of STX
vbt0									
vbK									
vbLinf									
wla									
wlb									
MaxAge			Age characterizations reflective of STX						Age characterizations reflective of STX
Cat		Known, informative of historical removals							
FMSY_M	Known								
Ind			Fishery dependent representative of population abundance, dependent upon accurate effort reporting						
Dep		Known, estimated from TIP samples and life history							
Abun	Known, estimated from current catch and F								

St. Croix spiny lobster: summary

- Tradeoffs between MPs highlight the importance of selecting performance criteria
- Considerable uncertainty present in data inputs for US Caribbean species highlights caution when selecting MPs for management advice

St. Croix spiny lobster assessment summary

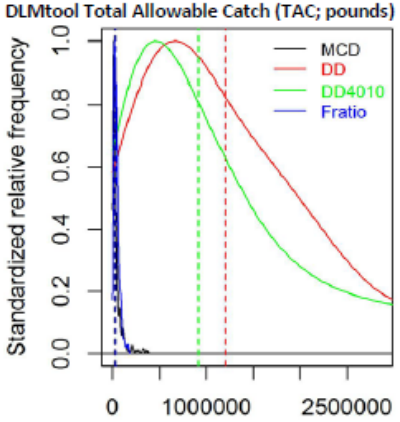
Spiny lobster (*Panulirus argus*) St. Croix diving

Management Evaluation Performance Results

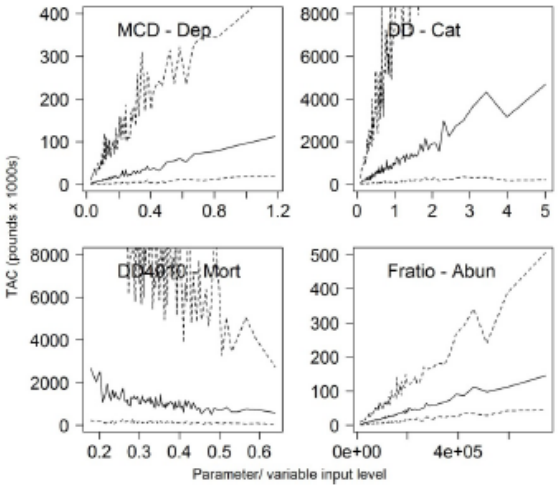
Ordered by PNOF				Ordered by LTY			
No	MP	PNOF	B50	No	MP	LTY	AAVY
1	Itarget4	98.7	96.1	1	MCD	70.7	72.8
2	DD4010	83.9	95.6	2	DD	69.6	99.0
3	DD	71.7	91.7	3	DD4010	66.6	75.0
4	MCD	66.4	94.1	4	Fratio	64.0	52.2
5	SPMSY	63.3	83.0	5	Islope1	50.8	97.2
6	Islope4	61.8	84.7	6	Itarget1	47.8	99.4
7	Islope1	60.8	84.8	7	Islope4	46.6	96.8
8	Fratio	60.0	86.5	8	SPMSY	40.7	94.2
9	Itarget1	51.8	85.3	9	Itarget4	0.0	71.6

PNOF = Prob. of not overfishing (%); **B50** = Prob. of B being above 0.5 BMSY (%); **LTY** = Relative long-term yield (fraction of simulations achieving > 50% FMSY yield over final 10 projection years); **AAVY** = fraction of simulations where average annual variability in yield < 15%

Distributions and Medians (dashed) for DLMtool Total Allowable Catch (TAC; pounds)



Subset of Catch Statistics Sensitivities:



DLMtool Catch Statistics (lbs)

MP	Min	Median	Max
Highest long-term yields in MSE			
DD	38,692	1,047,478	17,270,400
DD4010	24,497	894,563	23,764,310
Fratio	4,637	29,015	144,193
MCD	1,242	21,247	247,998
Other MPs that meet AP criteria			
Islope1	15,102	55,563	178,913
Itarget1	13,800	50,164	162,328
Islope4	11,589	47,936	146,667
SPMSY	1,356	39,761	80,001
Itarget4	10,098	30,551	107,502

Mean length estimator (Huynh)
none meet performance criteria

Catch Statistics (lbs)			
Catch	1,288	32,870	168,005
2014 Catch			39,681
2012–2014 Average Catch			62,025
1975-2014 Average Catch			53,134

Concerns and Caveats:

- **Method-specific assumptions** (e.g., constant M)
- **Sensitivity to data inputs**: life history parameters, depletion, and abundance
- **Data quality**: uncertainty in **MaxAge and Mort**; underreporting of **catch** ; Appropriateness of fishery-dependent **index of abundance**, estimates of **stock depletion** and **current abundance**, and appropriateness of TIP data in quantifying **length at first capture**

Considerations:

- Exclude MPs with catch recommendations near or exceeding maximum observed catches (DD/DD4010)
- Consider methods with high PNOF and LTY and weigh trade-offs in metrics

Results

- Species: stoplight parrotfish
- Island: St. Croix
- Gear: diving

Content:

- MSE
  - Operating model
  - Convergence
  - Tradeoffs & performance
- Catch calculations
- Catch sensitivities
- Guidance

Photo from NOAA Photo Library (http://www.photolib.noaa.gov/).

St. Croix stoplight parrotfish: Operating model (OM)

Base OM:

- Stock (15% variability)
- Fleet (Asymptotic)
- Observation (precise, unbiased)

Alternative OMs:

- Stock (5% variability)
- Fleet (Asymptotic)
- Observation (imprecise, biased)

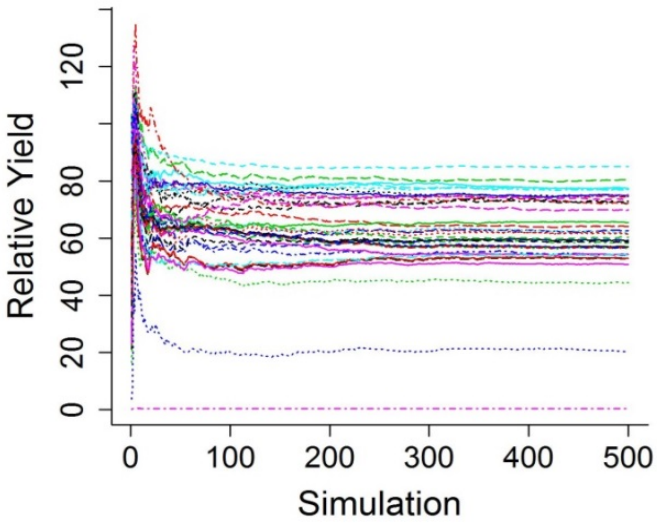
St. Croix stoplight parrotfish: MSE performance

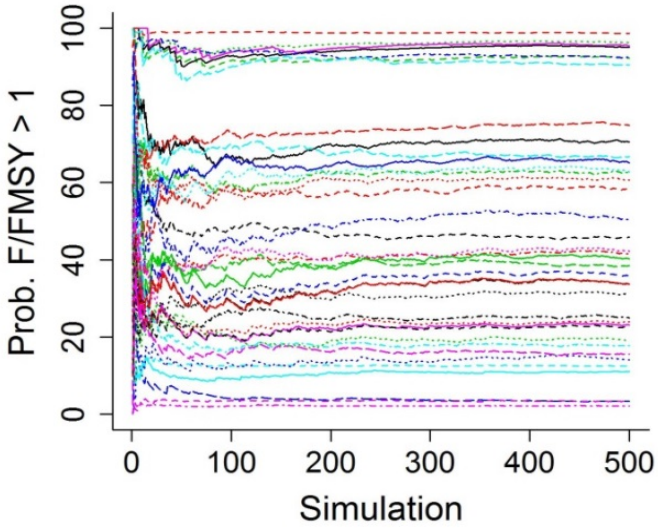
- Model convergence
- Tradeoff plots allow comparison of performance of feasible management procedures (MPs) between base and alternative OMs
  - MP feasibility defined by data sufficiency
  - Sensitivity to assumptions made within OM components (stock, observation model inputs)
    - Life history
    - Bias and quality of data inputs

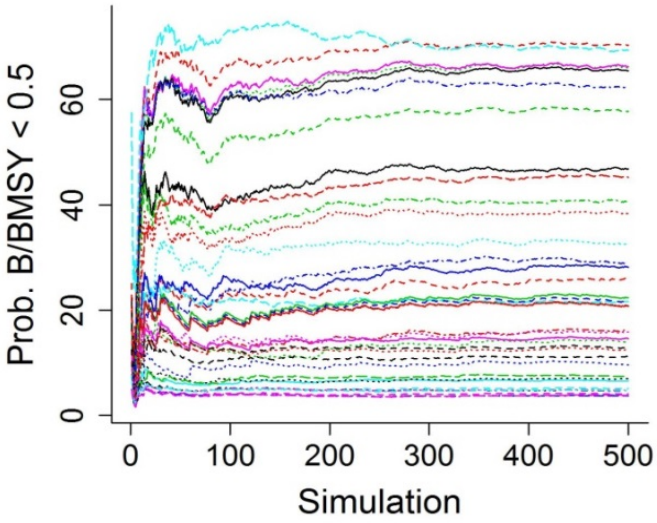
St. Croix stoplight parrotfish: Model convergence

Assumes:

- Base stock, fleet, and subclass scenarios
- n=500 sims, 250 reps







All MPs converged at threshold = 1%

Most MPs reached convergence by ~ 300 sims

St. Croix stoplight parrotfish: Tradeoffs in performance by MP

Assumes:

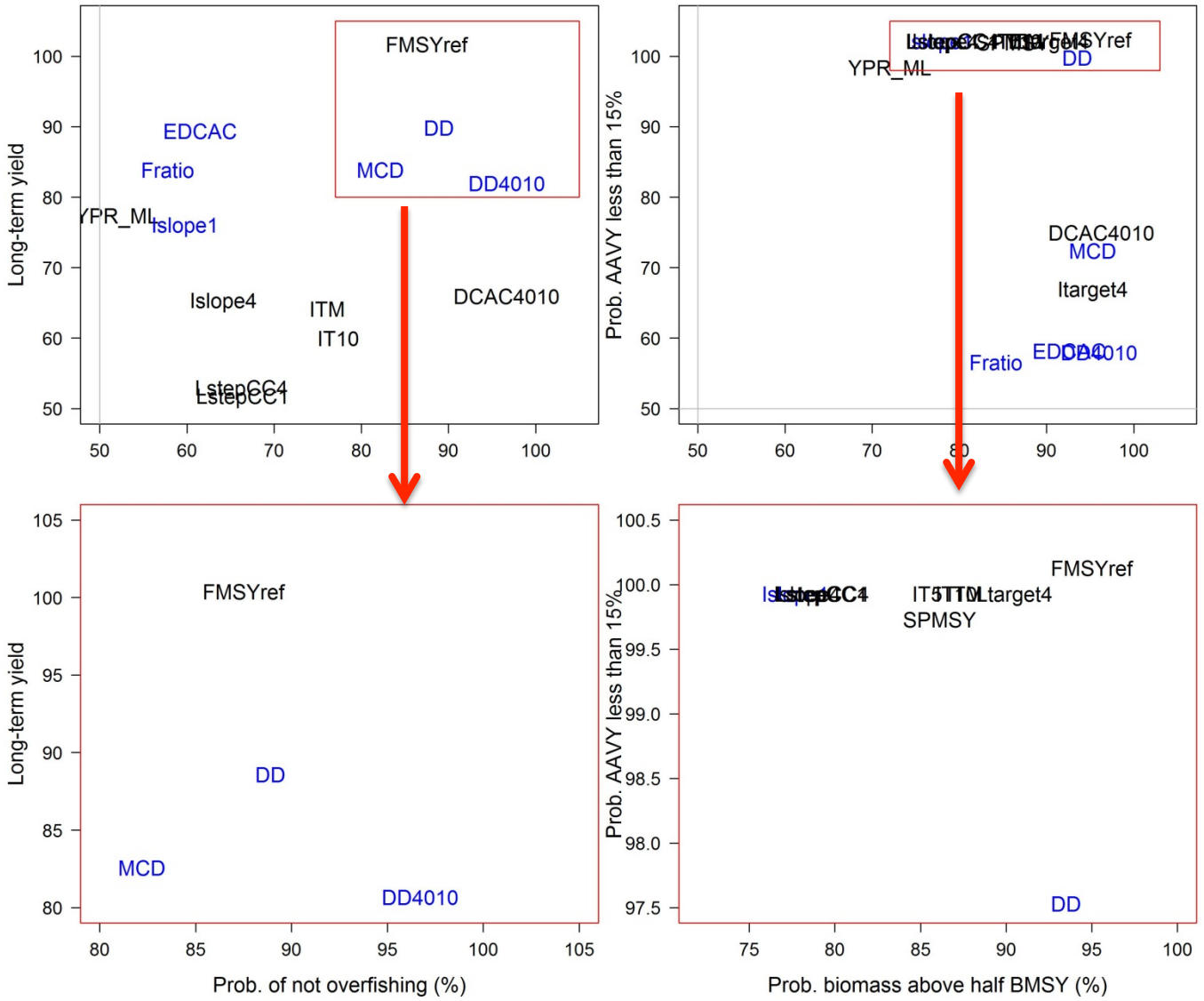
- Base stock, fleet, and subclass
- scenarios

Long-term yield:

- The fraction of simulations achieving over 50% FMSY yield over the final 10 years of the projection

FMSYref:

- Assumes perfect information



St. Croix stoplight parrotfish: MSE performance

	Base Stock					Alt Stock			
	15%LH, Asymptotic selex					5%LH, Asymptotic selex			
MP	PNOF	B50	LTY	AAVY	MP	PNOF	B50	LTY	AAVY
Reference MP									
FMSYref	87.5	95	99.3	100	FMSYref	87.7	93.4	99.2	99.8
MPs producing 6 highest long-term yields that meetAP criteria									
DD	88.9	93.5	87.5	97.4	EDCAC	66.5	91.3	87.3	54.2
EDCAC	61.5	92.6	87	55.8	DD	90.1	92.1	86	97.4
Fratio	57.8	84.2	81.5	54.2	MCD	87.9	93.9	80.8	68.4
MCD	82.2	95.3	81.5	70	DD4010	97	94.7	80.4	53.4
DD4010	96.7	96	79.6	55.6	Fratio	57.9	82.3	77.7	53.4
Islope1	59.8	77.7	73.7	99.8	Islope1	65.4	77	70.5	99.8
Other MPs producing lower long-term yields that meet AP criteria									
DCAC4010	96.7	96.3	63.6	72.6	DCAC4010	98.3	95	54.6	75.4
Islope4	64.2	78.4	63	99.8	Islope4	69.5	78.1	53.6	99.8
ITM	76.1	87.6	61.8	99.8	ITM	80.9	86.3	52.8	100
IT10	77.4	87.1	57.6	99.8	CC4	56.7	70.9	47.6	100
LstepCC4	66.3	79.3	50.6	99.8	IT10	81.2	85.8	47.4	100
LstepCC1	66.4	79.2	49.4	99.8	LstepCC1	71.8	78.8	39.4	99.8
IT5	76.9	85.4	44.2	99.8	LstepCC4	71.9	78.8	38.7	99.8
SPMSY	81	86.1	34.5	99.6	IT5	80	83.5	32.8	100
Ltarget4	85.9	90.5	13.3	99.8	SPMSY	80.9	83.8	28.6	99.4
Itarget4	97.9	95.3	0	64.6	Ltarget4	87.4	88.4	8.6	100
					Itarget4	97.7	93.5	0	64.6

Results for each OM sorted by long-term yield (LTY)

St. Croix stoplight parrotfish: MSE performance

	Base Stock					Alt Observation			
	15%LH, Asymptotic selex					Imprecise, biased			
MP	PNOF	B50	LTY	AAVY	MP	PNOF	B50	LTY	AAVY
Reference MP									
FMSYref	87.5	95	99.3	100	FMSYref	87.5	95	99.3	100
MPs producing 6 highest long-term yields that meetAP criteria									
DD	88.9	93.5	87.5	97.4	Islope1	61.8	76.1	55	98.6
EDCAC	61.5	92.6	87	55.8	Islope4	65	77	47.6	99.4
Fratio	57.8	84.2	81.5	54.2	ITM	72.2	83.6	45.9	99.8
MCD	82.2	95.3	81.5	70	IT10	73.4	83.5	41.2	99.8
DD4010	96.7	96	79.6	55.6	LstepCC4	67.5	78	40	99.6
Islope1	59.8	77.7	73.7	99.8	Itarget1	53.9	71.9	39.6	82.6
Other MPs producing lower long-term yields that meet AP criteria									
DCAC4010	96.7	96.3	63.6	72.6	LstepCC1	67.6	78.2	39.4	99.6
Islope4	64.2	78.4	63	99.8	CC4	55	70.1	38	93.4
ITM	76.1	87.6	61.8	99.8	IT5	73.8	82.1	36.2	99.6
IT10	77.4	87.1	57.6	99.8	SPMSY	76.7	83.2	34.5	99.8
LstepCC4	66.3	79.3	50.6	99.8	Ltarget4	73.2	81.7	23.6	82.2
LstepCC1	66.4	79.2	49.4	99.8					
IT5	76.9	85.4	44.2	99.8					
SPMSY	81	86.1	34.5	99.6					
Ltarget4	85.9	90.5	13.3	99.8					
Itarget4	97.9	95.3	0	64.6					

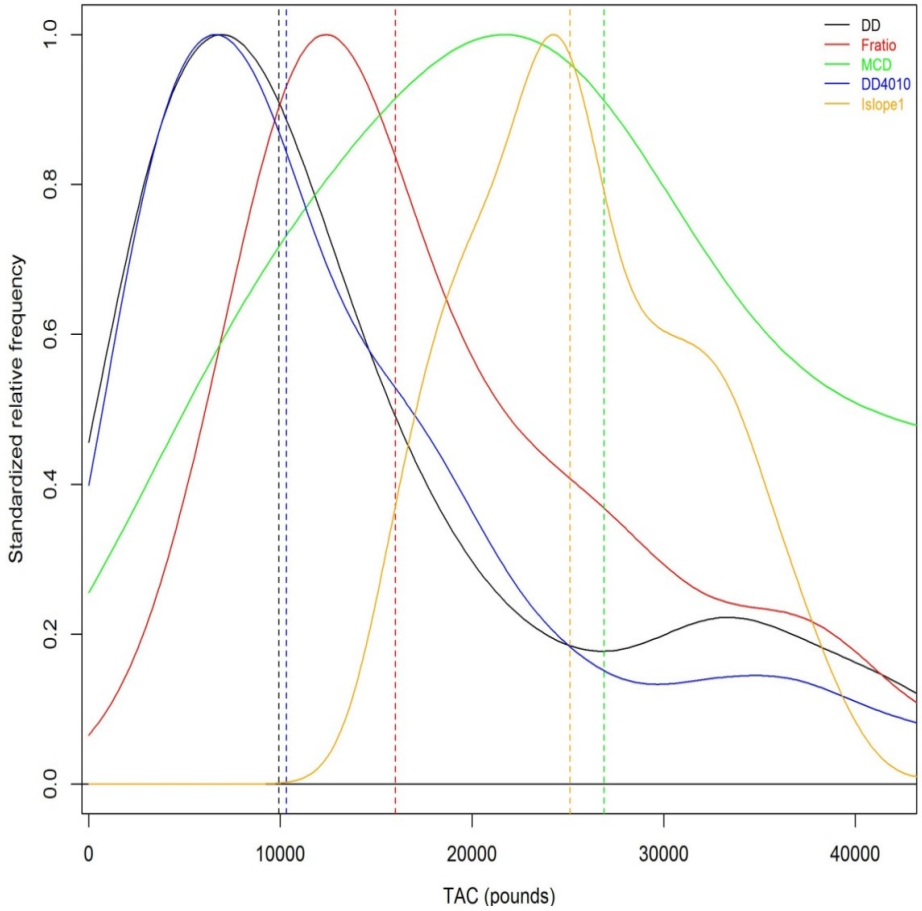
Results for each OM sorted by long-term yield (LTY)

St. Croix stoplight parrotfish: Catch recommendations

- **MPs shown** for catch recommendations which:
  - Met performance criteria specified by SEDAR 46 DW/AW Panel
  - Produced the highest relative long-term yields in the MSE relative to the FMSYref

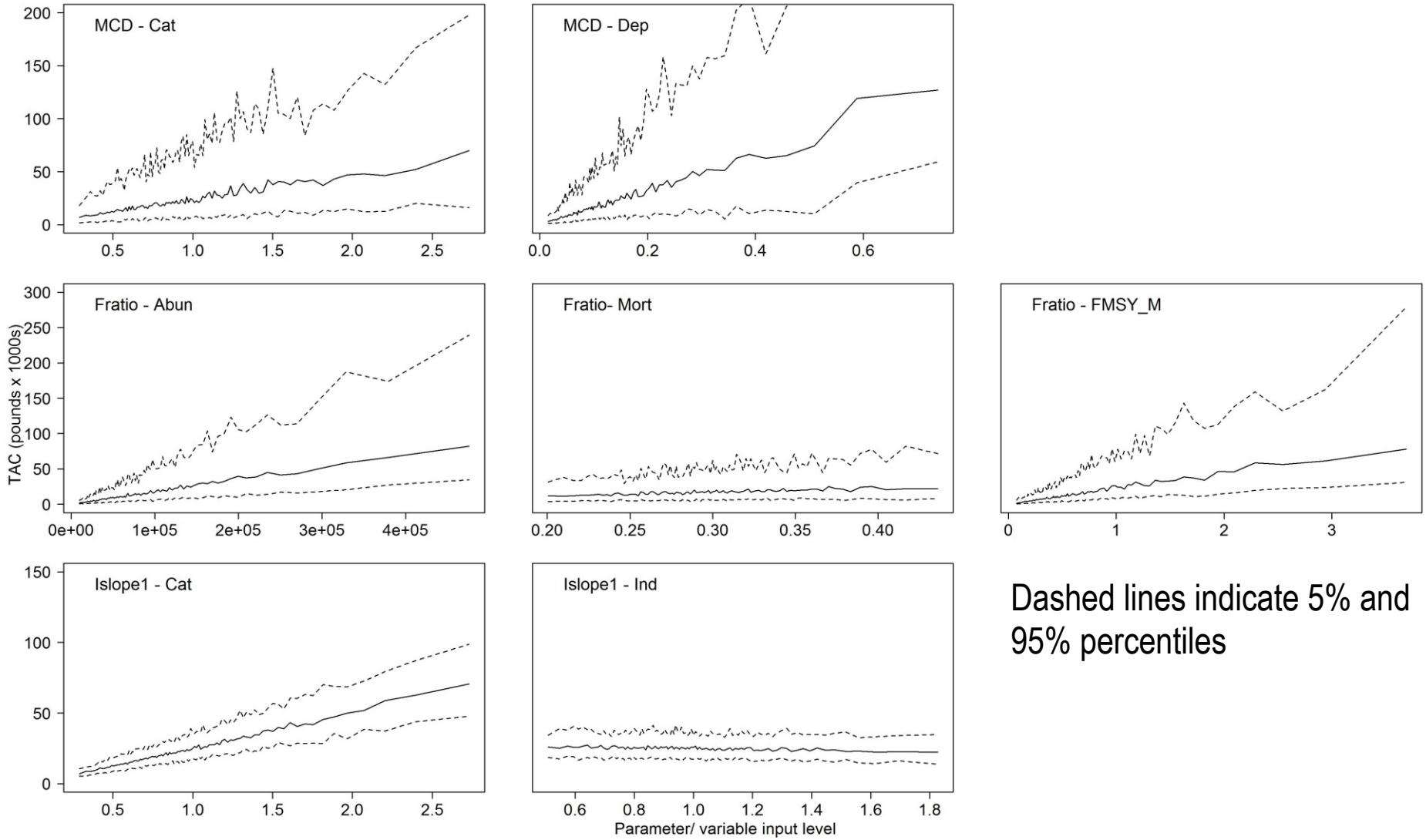
St. Croix stoplight parrotfish: Catch recommendations

	Summary statistics (TACs, in pounds)				
MP	Min	25th Percentile	Median	75th Percentile	Max
MPs producing 6 highest long-term yields that meet AP criteria					
Islope1	11,089	21,597	25,620	30,713	47,084
MCD	2,355	15,468	23,067	37,042	156,974
Fratio	1,391	10,335	15,415	26,771	107,133
DD4010	489	6,652	10,253	17,812	78,481
DD	757	5,652	9,749	17,309	90,988
Other MPs that meet AP criteria					
SPMSY	973	16,646	31,043	43,272	76,106
Islope4	11,312	16,826	19,912	23,810	34,876



Dashed lines indicate median value for each MP

St. Croix stoplight parrotfish: Catch sensitivity

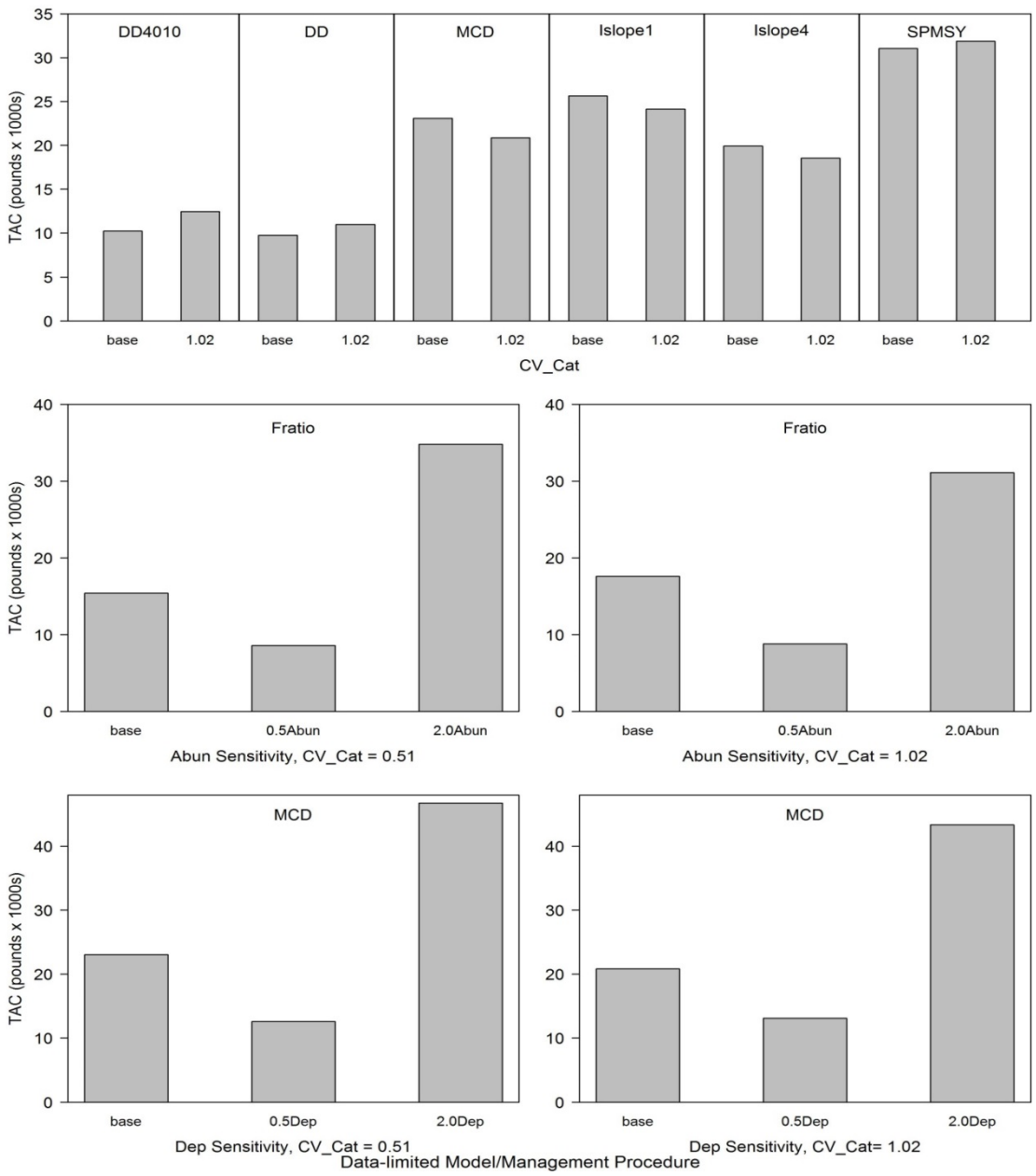


Dashed lines indicate 5% and 95% percentiles

St. Croix stoplight parrotfish: Catch sensitivity (cont'd)

Sensitivities:

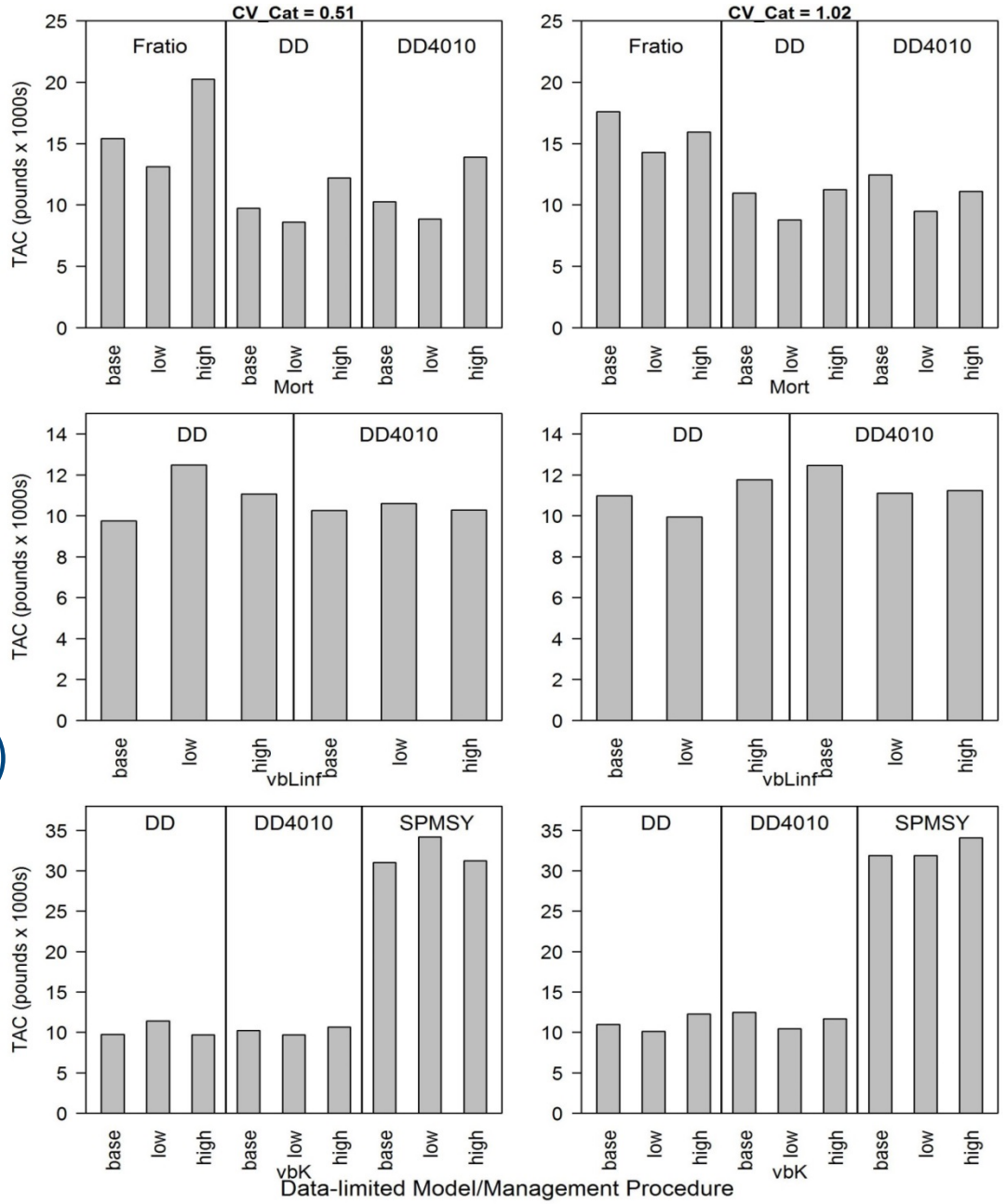
- CV_Catch = 0.51
  - 2 x CV_Catch (1.02)
- Depletion (0.15)
  - 2 X Dep
  - 0.5 x Dep
- Abundance (501,235)
  - 2 x Abun
  - 0.5 x Abun



St. Croix stoplight parrotfish: Catch sensitivity (cont'd)

Sensitivities:

- CV_Catch = 0.51
  - 2 x CV_Catch (1.02)
- LH (low, base, high)
  - Mort (0.16, 0.19, 0.22)
  - vbLinf (427, 502, 578)
  - vbK (0.12, 0.14, 0.16)



St. Croix stoplight parrotfish: Guidance table for comparing MPs

Considerations important in selecting between MPs:

- Performance metrics (PNOF, B50, LTY, AAVY) by method type:
  - Abundance-based
  - Depletion-based
  - Data moderate
  - Index-based
  - Catch-based
- Life history inputs (e.g., spatial relevance, confidence in estimates)
- Data inputs (bias in catch, selectivity, index of abundance, fleet representativeness)

St. Croix stoplight parrotfish: Guidance table

Considerations:

- Performance metrics

Parameter	Abun-based	Dep-based	Data-moderate	Data-moderate	Index-based	Index-based	Catch-based
	Fratio	MCD	DD	DD4010	Islope1	Islope4	SPMSY
PNOF	57.8	82.2	88.9	96.7	59.8	64.2	81
B50	84.2	95.3	93.5	96	77.7	78.4	86.1
LTY	81.5	81.5	87.5	79.6	73.7	63	34.5
AAVY	54.2	70	97.4	55.6	99.8	99.8	99.6
Mort	Known, constant across age		Known, constant across age				
L50			Life history characterizations reflective of STX				Life history characterizations reflective of STX
vbt0							
vbK							
vbLinf							
wla							
wlb							
MaxAge			Age characterizations reflective of STX				Age characterizations reflective of STX
Cat		Known, informative of historical removals					
FMSY_M	Known						
Ind			Fishery dependent representative of population				
Dep		Known, estimated from TIP samples and life history					
Abun	Known, estimated from current catch and F						

St. Croix stoplight parrotfish: Guidance table

Considerations:

- Uncertainty in growth parameters

Parameter	Abun-based	Dep-based	Data-moderate	Data-moderate	Index-based	Index-based	Catch-based
	Fratio	MCD	DD	DD4010	Islope1	Islope4	SPMSY
PNOF	57.8	82.2	88.9	96.7	59.8	64.2	81
B50	84.2	95.3	93.5	96	77.7	78.4	86.1
LTY	81.5	81.5	87.5	79.6	73.7	63	34.5
AAVY	54.2	70	97.4	55.6	99.8	99.8	99.6
Mort	Known, constant across age		Known, constant across age				
L50			Life history characterizations reflective of STX				Life history characterizations reflective of STX
vbt0							
vbK							
vbLinf							
wla							
wlb							
MaxAge			Age characterizations reflective of STX				Age characterizations reflective of STX
Cat		Known, informative of historical removals					
FMSY_M	Known						
Ind			Fishery dependent representative of population				
Dep		Known, estimated from TIP samples and life history					
Abun	Known, estimated from current catch and F						

St. Croix stoplight parrotfish: Guidance table

Considerations:

- Underreporting of catch & inconsistencies
- Representativeness of fleet: index of abundance

Parameter	Abun-based	Dep-based	Data-moderate	Data-moderate	Index-based	Index-based	Catch-based
	Fratio	MCD	DD	DD4010	Islope1	Islope4	SPMSY
PNOF	57.8	82.2	88.9	96.7	59.8	64.2	81
B50	84.2	95.3	93.5	96	77.7	78.4	86.1
LTY	81.5	81.5	87.5	79.6	73.7	63	34.5
AAVY	54.2	70	97.4	55.6	99.8	99.8	99.6
Mort	Known, constant across age		Known, constant across age				
L50			Life history characterizations reflective of STX				Life history characterizations reflective of STX
vbt0							
vbK							
vbLinf							
wla							
wlb							
MaxAge			Age characterizations reflective of STX				Age characterizations reflective of STX
Cat		Known, informative of historical removals					
FMSY_M	Known						
Ind			Fishery dependent representative of population				
Dep		Known, estimated from TIP samples and life history					
Abun	Known, estimated from current catch and F						

St. Croix stoplight parrotfish: Guidance table

Considerations:

- Highly uncertain estimates of depletion and current abundance

Parameter	Abun-based	Dep-based	Data-moderate	Data-moderate	Index-based	Index-based	Catch-based
	Fratio	MCD	DD	DD4010	Islope1	Islope4	SPMSY
PNOF	57.8	82.2	88.9	96.7	59.8	64.2	81
B50	84.2	95.3	93.5	96	77.7	78.4	86.1
LTY	81.5	81.5	87.5	79.6	73.7	63	34.5
AAVY	54.2	70	97.4	55.6	99.8	99.8	99.6
Mort	Known, constant across age		Known, constant across age				
L50			Life history characterizations reflective of STX				Life history characterizations reflective of STX
vbt0							
vbK							
vbLinf							
wla							
wlb							
MaxAge			Age characterizations reflective of STX				Age characterizations reflective of STX
Cat		Known, informative of historical removals					
FMSY_M	Known						
Ind			Fishery dependent representative of population				
Dep		Known, estimated from TIP samples and life history					
Abun	Known, estimated from current catch and F						

St. Croix stoplight parrotfish: summary

- Tradeoffs between MPs highlight the importance of selecting performance criteria
- Considerable uncertainty present in data inputs for US Caribbean species highlights caution when selecting MPs for management advice

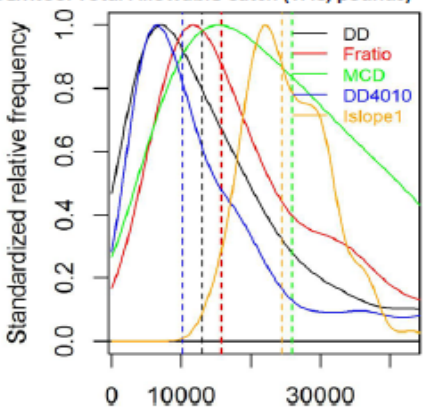
St. Croix stoplight parrotfish assessment summary

Stoplight parrotfish (*Sparisoma viride*) St. Croix diving

Management Evaluation Performance Results						
Ordered by PNOF				Ordered by LTY		
No	MP	PNOF	B50	No	MP	LTY	AAVY
1	DD4010	96.7	96.0	1	DD	87.5	97.4
2	DD	88.9	93.5	2	MCD	81.5	70.0
3	MCD	82.2	95.3	3	Fratio	81.5	54.2
4	SPMSY	81.0	86.1	4	DD4010	79.6	55.6
5	Islope4	64.2	78.4	5	YPR_ML	75.0	96.0
6	Islope1	59.8	77.7	6	Islope1	73.7	99.8
7	Fratio	57.8	84.2	7	Islope4	63.0	99.8
8	YPR_ML	52.0	72.0	8	SPMSY	34.5	99.6

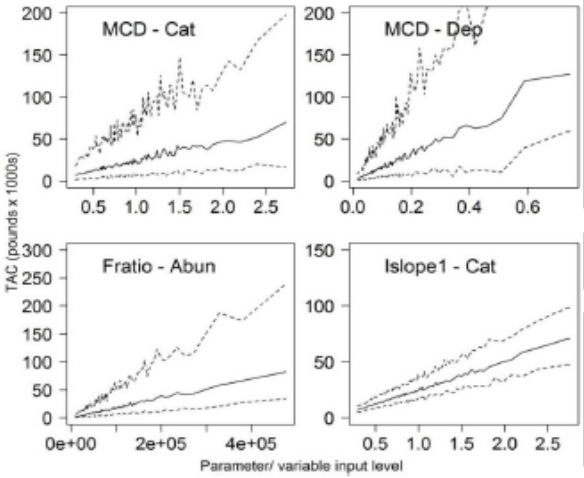
PNOF = Prob. of not overfishing (%); **B50** = Prob. of B being above 0.5 BMSY (%); **LTY** = Relative long-term yield (fraction of simulations achieving > 50% FMSY yield over final 10 projection years); **AAVY** = fraction of simulations where average annual variability in yield < 15%

Distributions and Medians (dashed) for DLMtool Total Allowable Catch (TAC; pounds)



DLMtool Catch Statistics (lbs)			
MP	Min	Median	Max
Highest long-term yields in MSE			
Islope1	11,089	25,620	47,084
MCD	2,355	23,067	156,974
Fratio	1,391	15,415	107,133
DD4010	489	10,253	78,481
DD	757	9,749	90,988
Other MPs that meet AP criteria			
SPMSY	973	31,043	76,106
Islope4	11,312	19,912	34,876

Subset of Catch Statistics Sensitivities:



Mean length estimator (Huynh)	
YPR_ML (F0.1)	21,374

Catch Statistics (lbs)			
Catch	20,152	98,980	164,576
2014 Catch			21,750
2012–2014 Average Catch			32,464
1996-2014 Average Catch			90,089

Concerns and Caveats:

- **Method-specific assumptions** (e.g., constant M)
- **Sensitivity to data inputs**: life history parameters, depletion, and abundance
- **Data quality**: uncertainty in **growth parameters**; underreporting of catch and inconsistency in recording parrotfish in data files; Appropriateness of fishery-dependent **index of abundance** to characterize trends in fishery resource, estimates of **stock depletion** and **current abundance**, and appropriateness of TIP data for diving fishery in quantifying **length at first capture**

Considerations:

- Consider methods with high PNOF and LTY and weigh trade-offs in metrics

SEDAR 46 stock evaluation summary: DLMtool

- General results
- Top performing MPs
- Catch recommendations
- Limitations of real world application – Data quality
- DLMtool software limitations
- Research recommendation to improve application
- Recommendations from SEDAR 46 for setting ACLs
- Proposed roadmap forward

General Results

Sufficiency of data to apply the DLMtool:

- 37 MPs identified as “feasible” satisfying data requirements for at least 1 MP
- 22 MPs of the “feasible MPs” met the performance criteria specified by the SEDAR 46 DW/AW workshop for at least 1 species-island unit

***MP convergence*:**

- All feasible MPs converged across all six species-island units (1% criterion)
- MP convergence generally reached between 200 - 300 simulations depending upon species-island units and all by 500

Identification of top 6 performing MPs+ by species-island units:

PR hogfish	PR yellowtail Snapper	STT queen triggerfish	STT spiny lobster	STX spiny lobster	STX stoplight parrotfish
DD4010	DD4010	DD	EDCAC	EDCAC	DD
DD	DD	EDCAC	MCD	MCD	EDCAC
EDCAC	MCD	DD4010	DD	DD	Fratio
MCD	Fratio	MCD	DD4010	DD4010	MCD
Fratio	DCAC4010	Fratio	DCAC4010	Fratio	DD4010
BK	DCAC	Islope1	Islope1	DCAC4010	Islope1

Data-moderate Depletion-based
Abundance-based Index-based

+Note that if data are assumed imprecise and biased, index-based methods perform best

Catch recommendation using real world data

Considerations:

- Selection of MP for providing TAC for management should take into account:
    - Sensitivity of MPs to input parameters
    - Are MP assumptions met or violated
    - Information quality used in interpretation of results
        - Are depletion and/or abundance estimates reasonable?
        - Are life history inputs reflective of the species island unit?
- Some MPs produced unrealistic catch levels
    - e.g., Delay Difference

Limitations of real world application– Data quality

Total removals:

- Species identification or mis-identification could influence landings
- Availability on reporting forms

Indices of abundance:

- Derived from fishery-dependent data sources
- Nominal indices

Length composition:

- Restricted to 1 fishery in SEDAR 46

Depletion & Current Abundance:

- Rough estimates

Limitations – DLMtool (v2.1.2) software

- Does not fully account for the range of hypotheses regarding population structure and cannot realize the full complexity of the biology such as:
  - Time- and age-varying natural mortality
  - Hermaphroditism
- Cannot realize the full complexity of the fishery such as:
  - Multiple fleets or gear types
  - Changes in fishing operations
  - Regulations
  - Real world application of data-limited methods assumes knife-edge selectivity
- Does not allow for implementation error of the harvest control rule within MSE
- Mean length (ML) methods not included in MSE due to computational constraints*

Research recommendations to better inform results

- Conduct a statistical review of existing fishery independent surveys
  - Identify an optimum sampling design for development of fishery independent abundance indices.
- Develop indices of abundance for spiny lobster using all available data since 1970s with a focus on a fishery independent survey
- Investigate more justifiable estimates of stock depletion (Dep) and depletion over time (Dt)
  - E.g., Productivity-Susceptibility Analysis (e.g., Cope et al. 2015)
- Investigate more justifiable estimates of current stock abundance
  - E.g., use F from mean length estimator

Research recommendations

- Enhanced catch at length by gear sampling is needed to better inform selectivity at age
- Investigate fleet dynamics to more accurately capture fishery characteristics
- Identify:
  - Target catch or index level(s) (used with catch and index time series)
  - Target length level(s) (used with catch and a length frequency series)
- Develop a weighting scheme for length composition and multiple gear fisheries reflective of the stock
- Consider organizing species into species complexes for assessment based on similar life history, market characteristics, and vulnerability

Recommendations from SEDAR 46 for setting ACLs

- Conduct a transparent review process of data-limited methods used to set ACLs similar to the workshop conducted by the Pacific Fishery Management Council (PFMC) SSC (NMFS 2011) be conducted.

- Specific considerations for review included:
  - What are the data requirements and assumptions of the method?
  - What are the conditions under which the method is applicable?
  - Is the method correct from a technical perspective?
  - How robust are model results to departures from model assumptions and atypical data inputs?
  - Incorporation of model uncertainty
  - Identify process to evaluate model results that incorporates objectivity, transparency (i.e., simulation/ management strategy evaluation)
  - What level of review is appropriate for assessments conducted using the method?

Recommendations (continued)

- Draw from SEDAR 46 DLMtool sensitivity results to identify data collection priorities
- Convene a workshop to review demographic data for all species in US Caribbean

Proposed roadmap for using DLMtool to set ACLs in the US Caribbean

- Borrowing from the Mid-Atlantic black sea bass evaluation, ***MPs could be selected if*** they are adaptive and rely on data that are routinely collected and believed to be reliable.

- Selection of MPs should at a minimum consider:
  - Performance metrics within a management strategy evaluation for each species
  - Considerations as to how well the data and model assumptions were met

MPs excluded from giving management advice

Acceptance Issue	PR_Hog	PR_YT	STT_QT	STT_SL	STX_SL	STX_Stop	Research Recommendations
Data quality							
Depletion uncertain	~~MCD~~	~~MCD~~	~~MCD~~	~~MCD~~	~~MCD~~	~~MCD~~	Convene expert team to develop estimates of depletion, explore Productivity-Susceptibility Analysis
Current Abundance uncertain	~~Fratio, BK~~	~~Fratio~~	~~Fratio~~		~~Fratio~~	~~Fratio~~	Convene expert team to develop estimates of current abundance using better estimates of F (e.g., from mean length approaches)
Life history							Convene workshop to characterize LH demographics and uncertainty estimates
Uncertain maximum Age and/or Mort			~~DD, DD4010, SPMSY~~	~~DD, DD4010, SPMSY~~	~~DD, DD4010, SPMSY~~		
Protogyny	~~SPMSY, DD, DD4010~~						
Uncertain growth parameters						~~DD, DD4010, SPMSY, YPR_ML~~	

MPs excluded from giving management advice

Acceptance Issue	PR_Hog	PR_YT	STT_QT	STT_SL	STX_SL	STX_Stop	Research Recommendations
Index of abundance restricted						~~Islope1, Islope4~~	Develop statistically robust fishery-independent surveys
Unrealistic results							
Catch recommendations exceeding or near largest observed catches	~~DD, DD4010~~	~~DD, DD4010~~	~~DD, DD4010~~	~~DD, DD4010~~	~~DD, DD4010~~		Further investigation into discard estimates, catch reporting and verification
Unacceptable performance in MSE							
Long-term yield < 50% relative to FMSYref	~~Itarget1, CC4~~	~~Itarget1, CC4~~	~~SPMSY~~	~~CC4, SPMSY, Itarget1, Itarget4~~	~~Islope4, Itarget1, Itarget4, SPMSY~~	~~SPMSY~~	Convene methods workshop to develop framework for harvest control rule approaches for data limited stocks (e.g., PFMC)

MPs selected for management advice

Recommended methods	PR_Hog	PR_YT	STT_QT	STT_SL	STX_SL	STX_Stop
Index-based	Islope1, Islope4	Islope1, Islope4	Islope1, Islope4, Itarget1	Islope1, Islope4	Islope1	-
Catch-based	-	SPMSY	CC4	-	-	-
Length-based	Mean Length Estimator (YPR_ML)	Mean Length Estimator (YPR_ML)	Mean Length Estimator (YPR_ML)	-	-	-

- Indicates no methods recommended

Thank you

Questions and comments