Stock Assessment of American Eel in the U.S.

Presentation to the
American Eel Management Board
Alexandria, VA
1 May 2012

Outline

- Fisheries & Exports
- Regional Approach
- Evaluation of Data
- Analyses
- Stock Status & Discussion
- Research Recommendations

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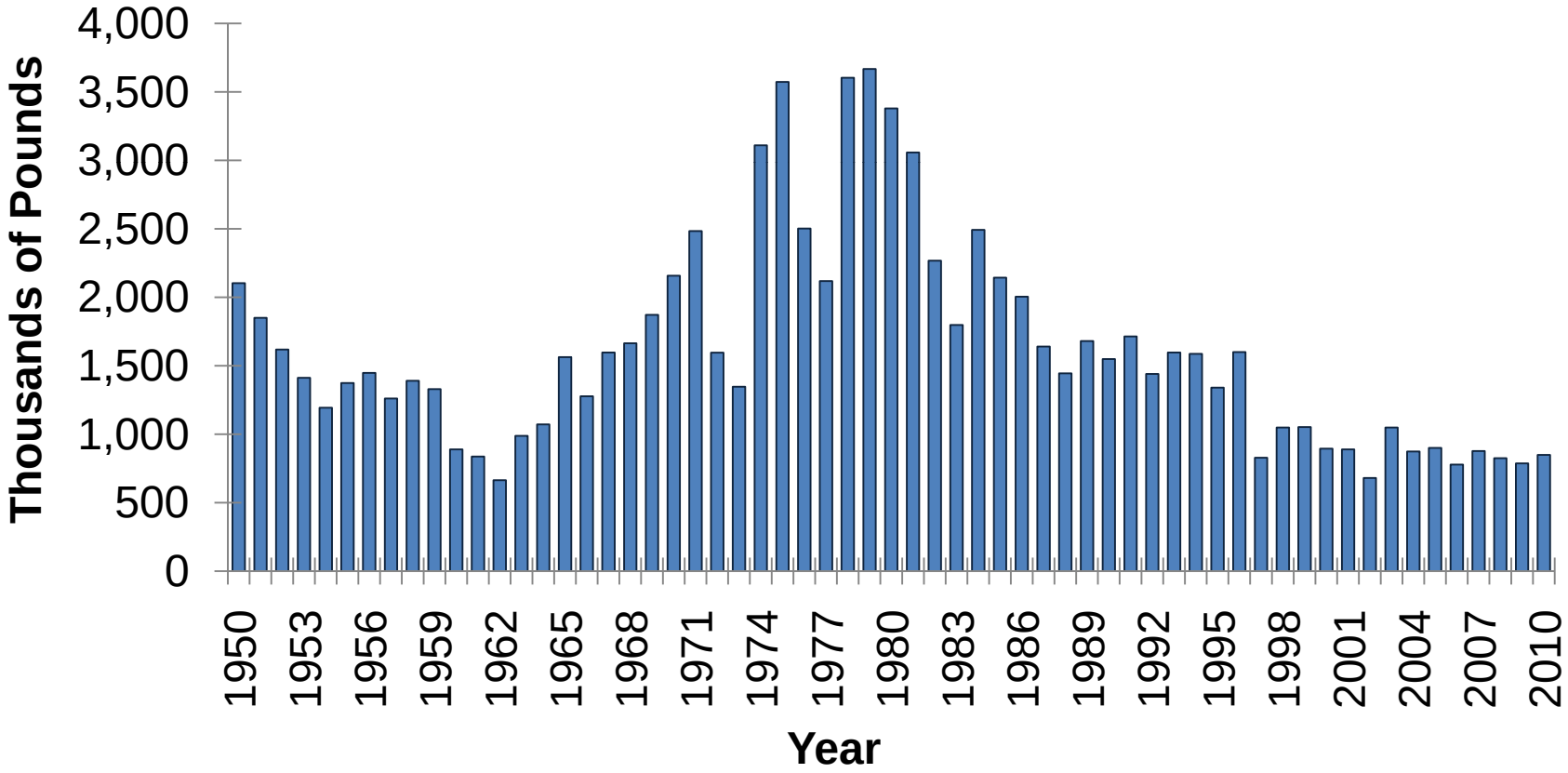
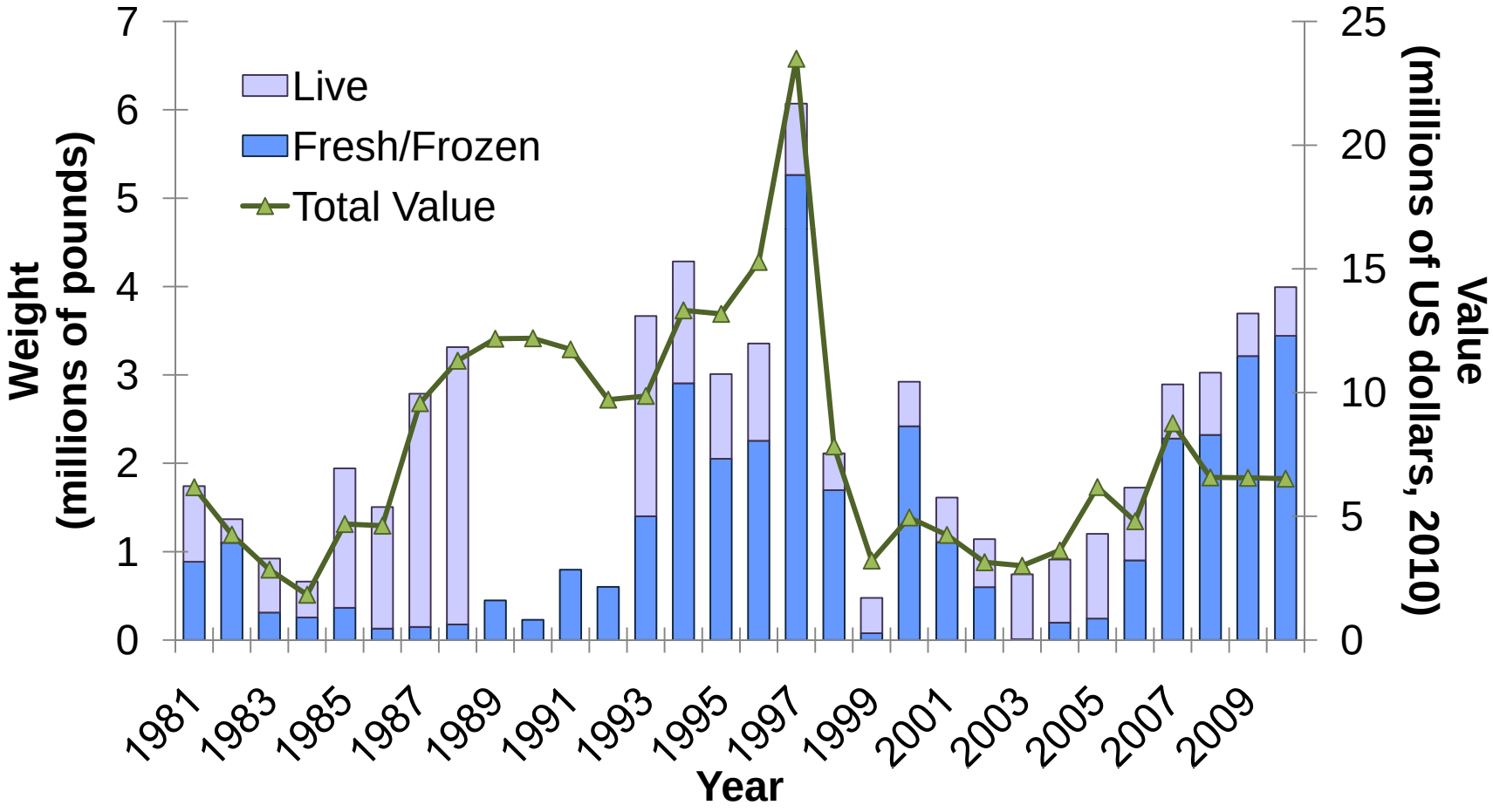
Fisheries & Exports
Commercial Landings



Fisheries & Exports

Exports



Fisheries & Exports

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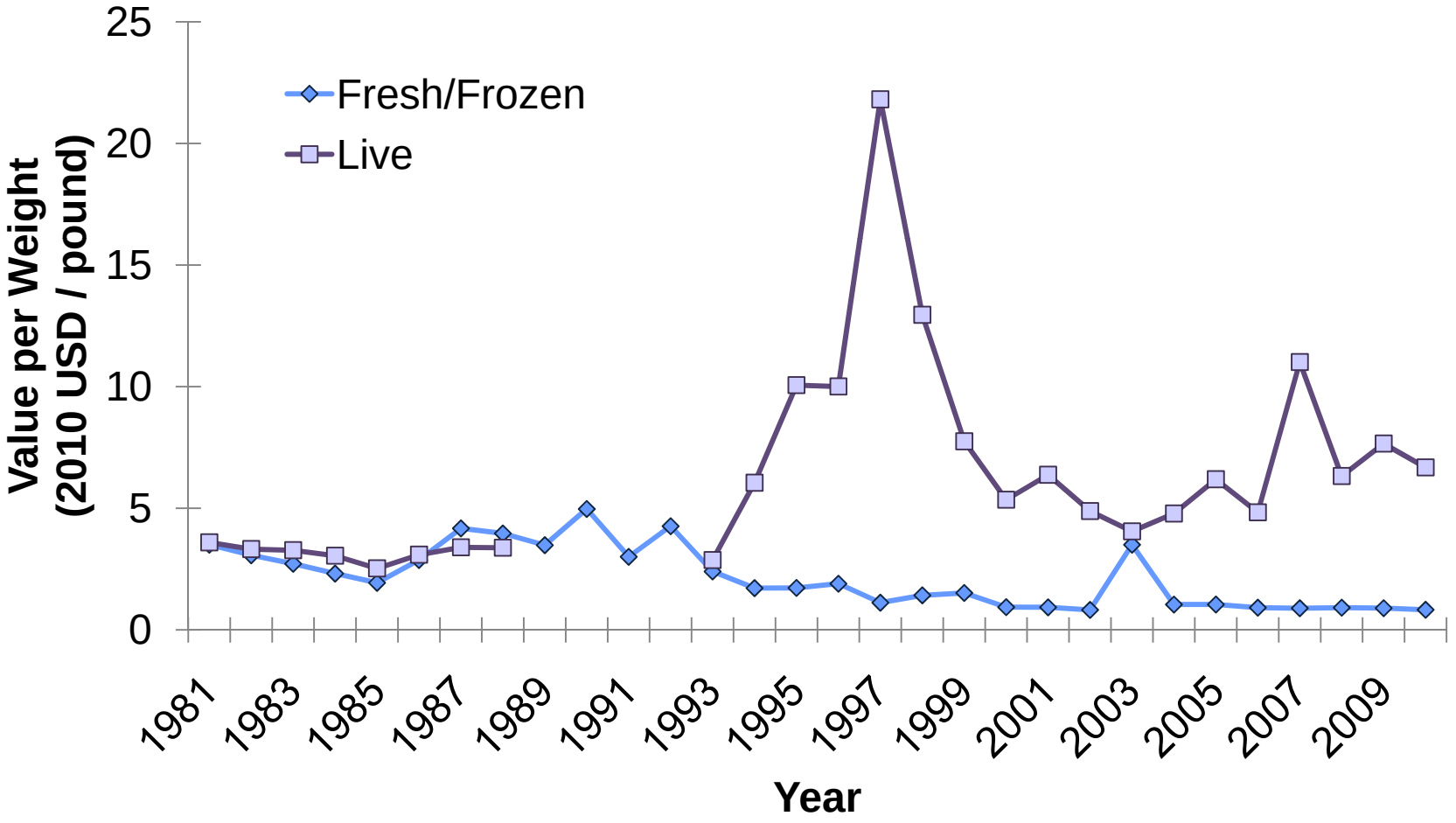
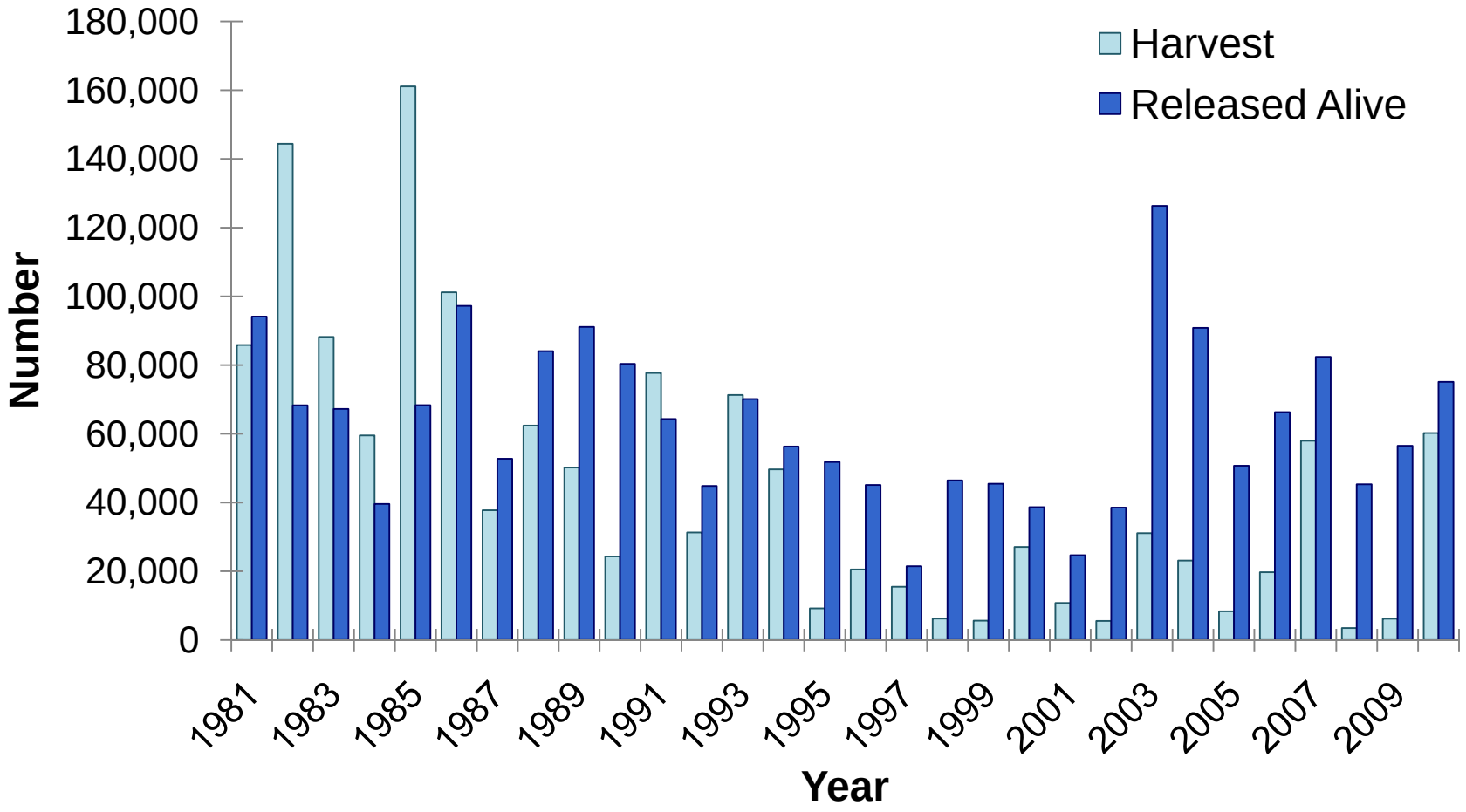


Fisheries & Exports
Recreational Catch



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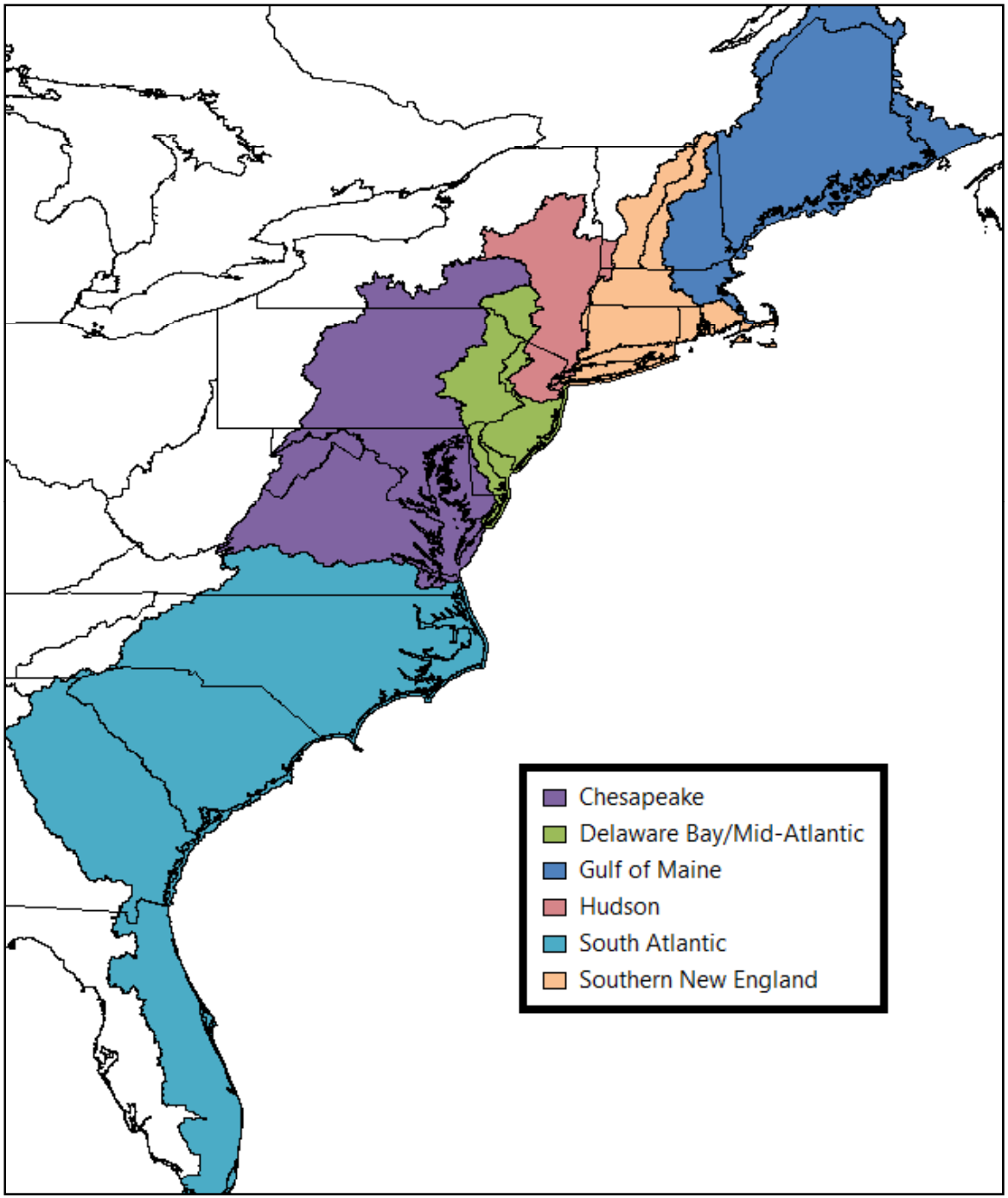
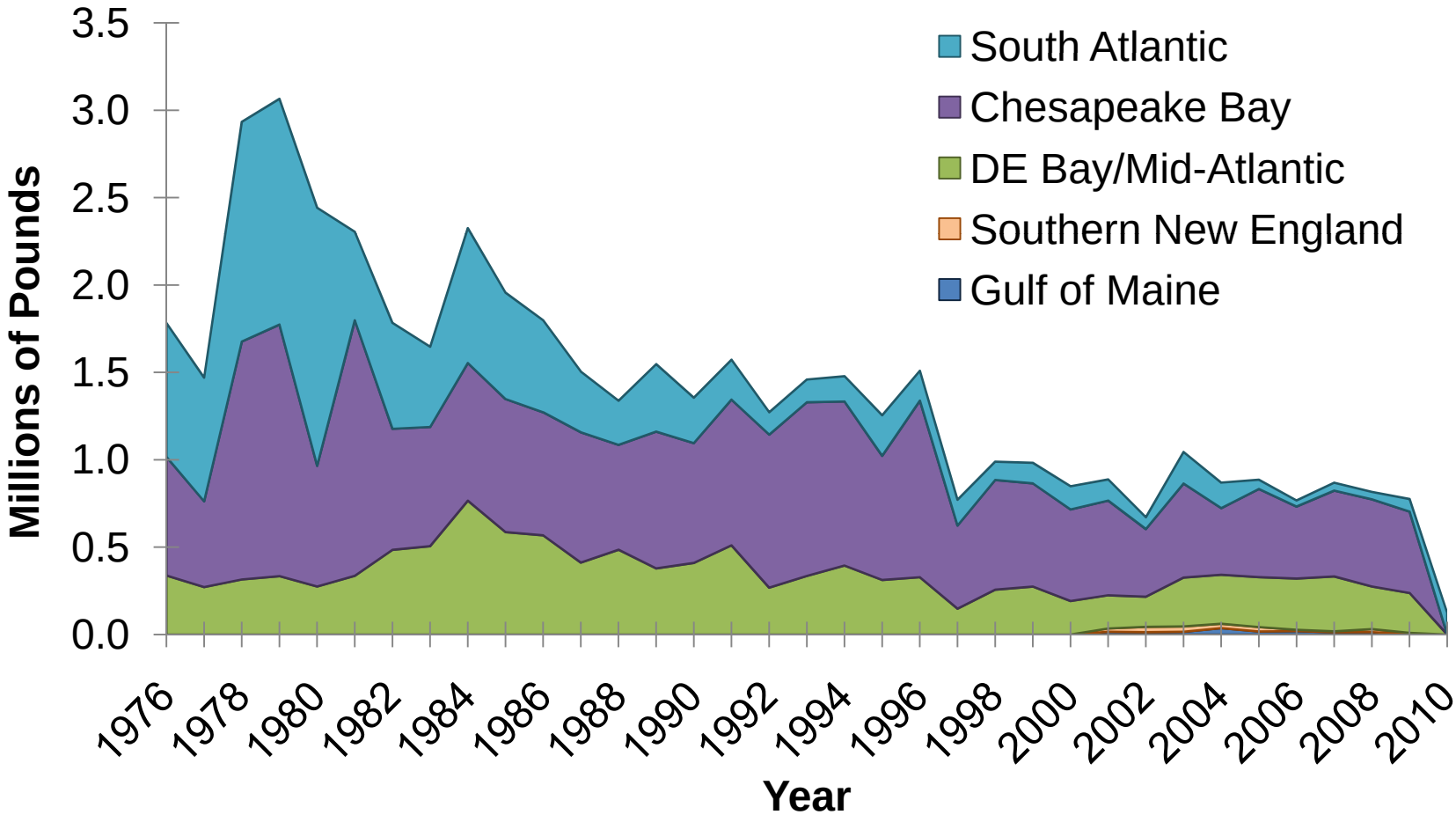

Chesapeake
Delaware Bay/Mid-Atlantic
Gulf of Maine
Hudson
South Atlantic
Southern New England

Regional Approach
Commercial Landings



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Evaluation of Data

- All available biological data used
- Fisheries-dependent CPUE
  - Trends described
  - Not included in analyses
- Fisheries-independent indices
  - ~70 different data sources
  - Selection criteria

Evaluation of Data
Fisheries-Independent Indices

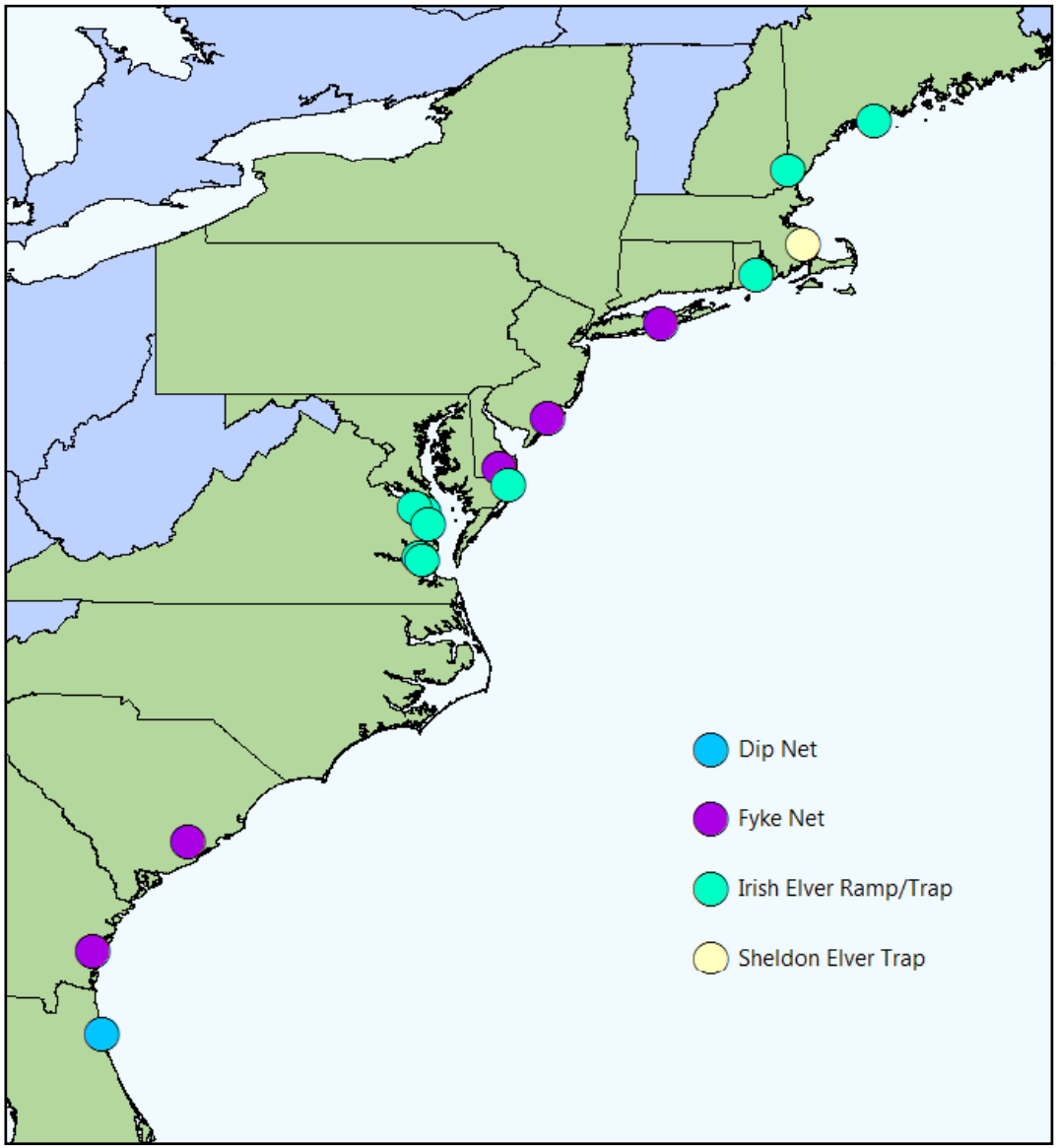
- Minimum 10 years
- Consistent methodology or can account for changes
- Adequate catches of eel
- Sample timing and spatial coverage
- Catchability

Evaluation of Data

Selected Data Sources—YOY Surveys

State	Site	Gear	Start Year
Maine	West Harbor Pond	Irish Elver Ramp	2001
New Hampshire	Lamprey River	Irish Elver Trap	2001
Massachusetts	Jones River	Sheldon Elver Trap	2001
Rhode Island	Gilbert Stuart Dam	Irish Elver Ramp	2000
New York	Carman's River	Fyke Net	2000
New Jersey	Patcong Creek	Fyke Net	2000
Delaware	Millsboro Dam	Fyke Net	2000
Maryland	Turville Creek	Irish Elver Ramp	2000
PRFC	Clark's Millpond	Irish Elver Ramp	2000
	Gardy's Millpond	Irish Elver Ramp	2000
Virginia	Bracken's Pond	Irish Elver Ramp	2000
	Kamp's Millpond	Irish Elver Ramp	2000
	Wormley Creek	Irish Elver Ramp	2001
South Carolina	Goose Creek	Fyke Net	2000
Georgia	Altamaha Canal	Fyke Net	2001
Florida	Guana River Dam	Dip Net	2001

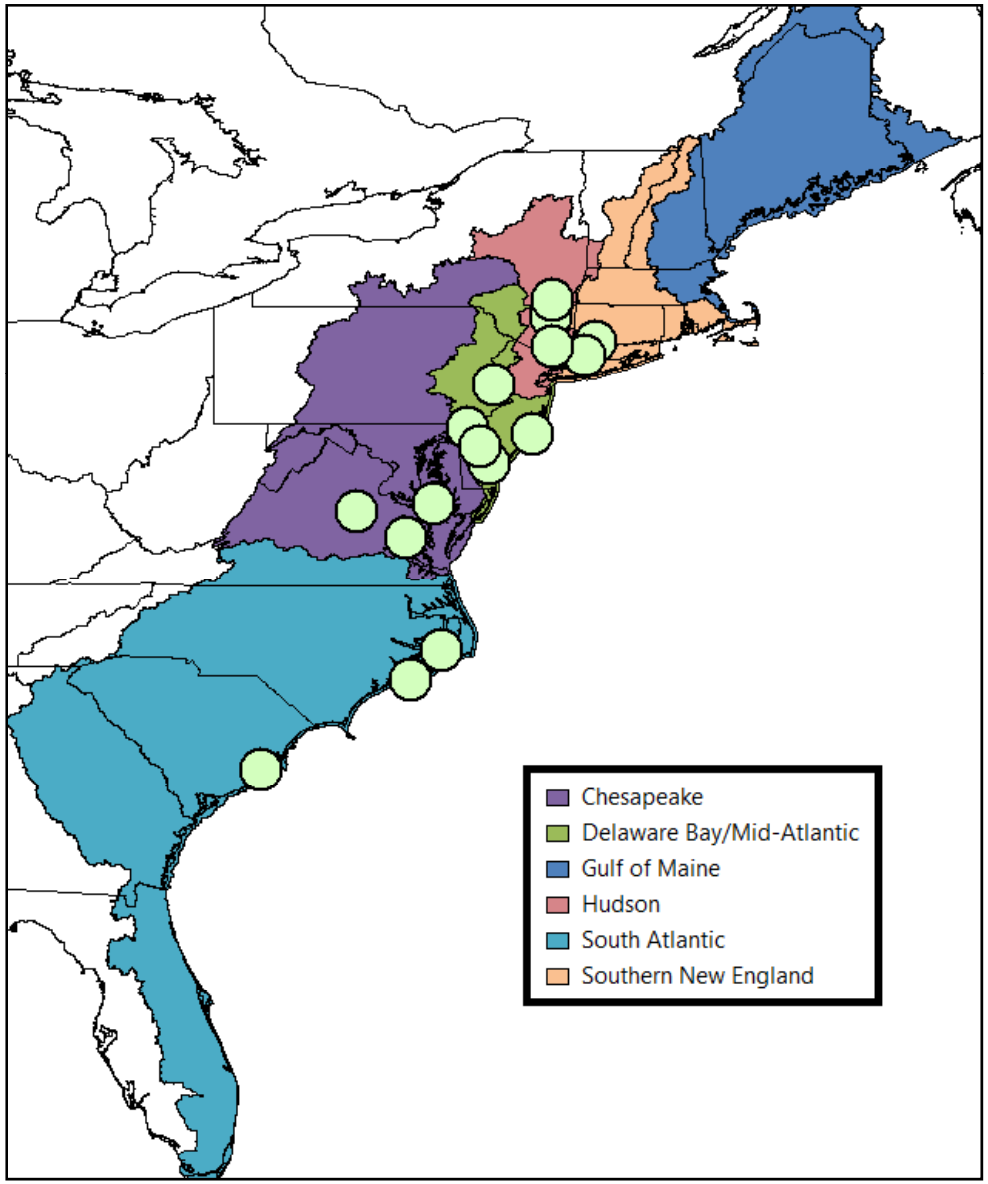
ASMFC-Mandated YOY Surveys



Evaluation of Data
Selected Data Sources—Other

Region	State	Survey	Gear	Life Stage	Start	Recent
Southern New England	CT	CTDEP Electrofishing	Electrofishing	Elver & Yellow	2001	2010
	NY	Western Long Island Sound	Seine	Yellow	1984	2010
Hudson River	NY	HRE Monitoring Program	Epibenthic sled & Tucker trawl	YOY	1974	2009
	NY	HRE Monitoring Program	Epibenthic sled & Tucker trawl	Yearling and Older	1974	2009
	NY	NYDEC Alosine Beach Seine	Seine	Elver & Yellow	1980	2009
	NY	NYDEC Striped Bass Beach Seine	Seine	Elver & Yellow	1980	2009
Del Bay/Mid-Atlantic Coastal Bays	NJ	Little Egg Inlet Ichthyoplankton	Ichthyoplankton Net	YOY	1992	2010
	NJ	NJDEP Striped Bass Seine	Seine	Yellow	1980	2009
	DE	Delaware Trawl	Trawl	Elver & Yellow	1982	2010
	DE	PSEG Trawl	Trawl	Elver & Yellow	1970	2010
	PA	Area 6 Electrofishing	Electrofishing	Elver	1999	2010
Chesapeake Bay	MD	MDDNR Striped Bass Seine	Seine	Yellow	1966	2010
	VA	North Anna Electrofishing	Electrofishing	Elver & Yellow	1990	2009
	VA	VIMS Juvenile Striped Bass—short	Seine	Yellow	1989	2010
	VA	VIMS Juvenile Striped Bass—long	Seine	Yellow	1967	2010
South Atlantic	NC	Beaufort Inlet Ichthyoplankton	Ichthyoplankton Net	YOY	1987	2003
	NC	NCDMF Estuarine Trawl	Trawl	Elver & Yellow	1989	2010
	SC	SC Electrofishing	Electrofishing	Elver & Yellow	2001	2010

Other Fishery-Independent Sources



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Analyses

- Index standardization
- Regional & coast-wide indices
- Growth modeling
- Trend analyses
- Depletion-Based Stock Reduction Analysis (DB-SRA)

Analyses

- **Index standardization**
- Regional & coast-wide indices
- Growth modeling
- Trend analyses
- Depletion-Based Stock Reduction Analysis (DB-SRA)

Index Standardization

- Purpose → remove extraneous factors influencing relative abundance
- GLM standardization
- Applied to both YOY and non-YOY indices

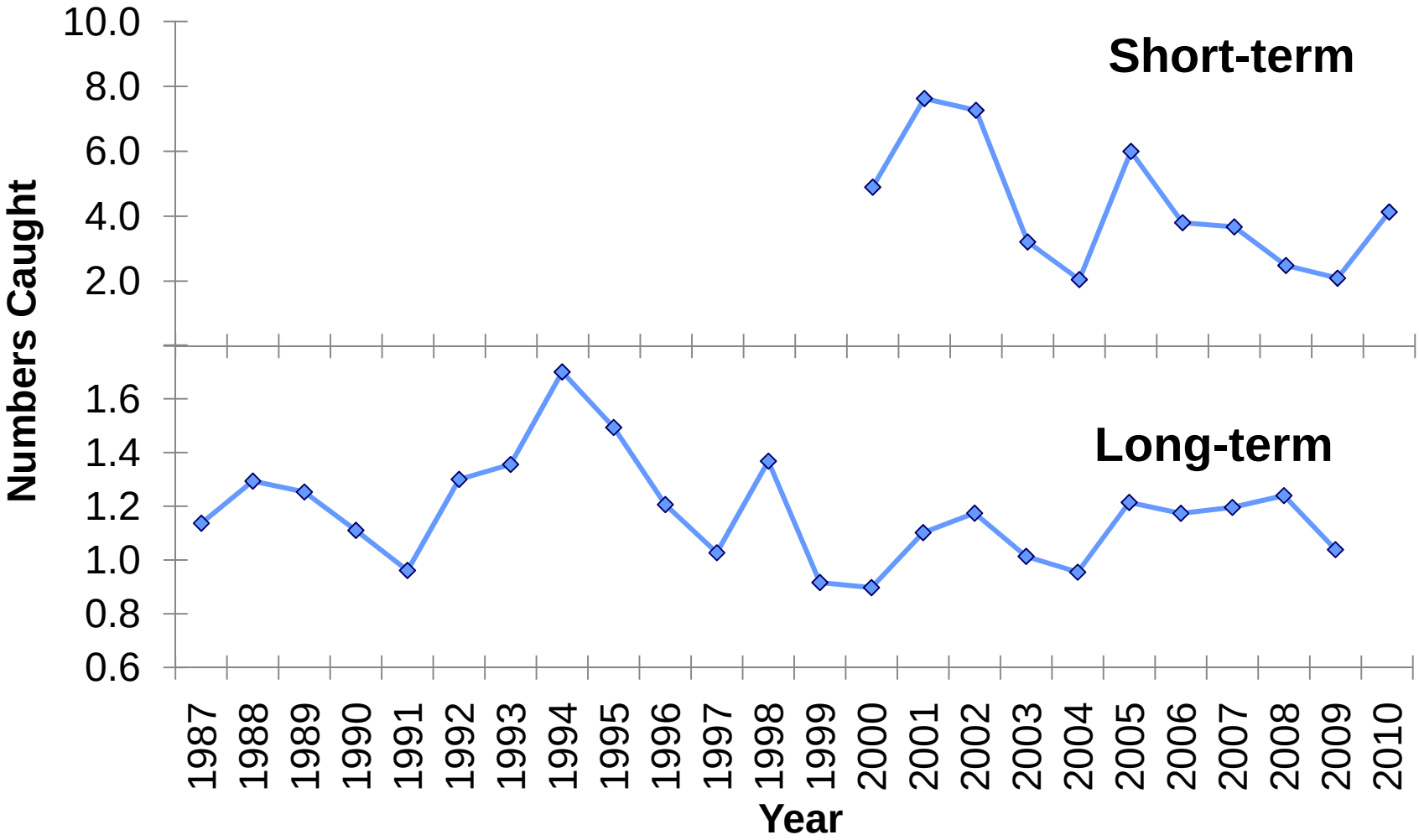
Analyses

- Index standardization
- **Regional & coast-wide indices**
- Growth modeling
- Trend analyses
- Depletion-Based Stock Reduction Analysis (DB-SRA)

Regional & Coast-wide Indices

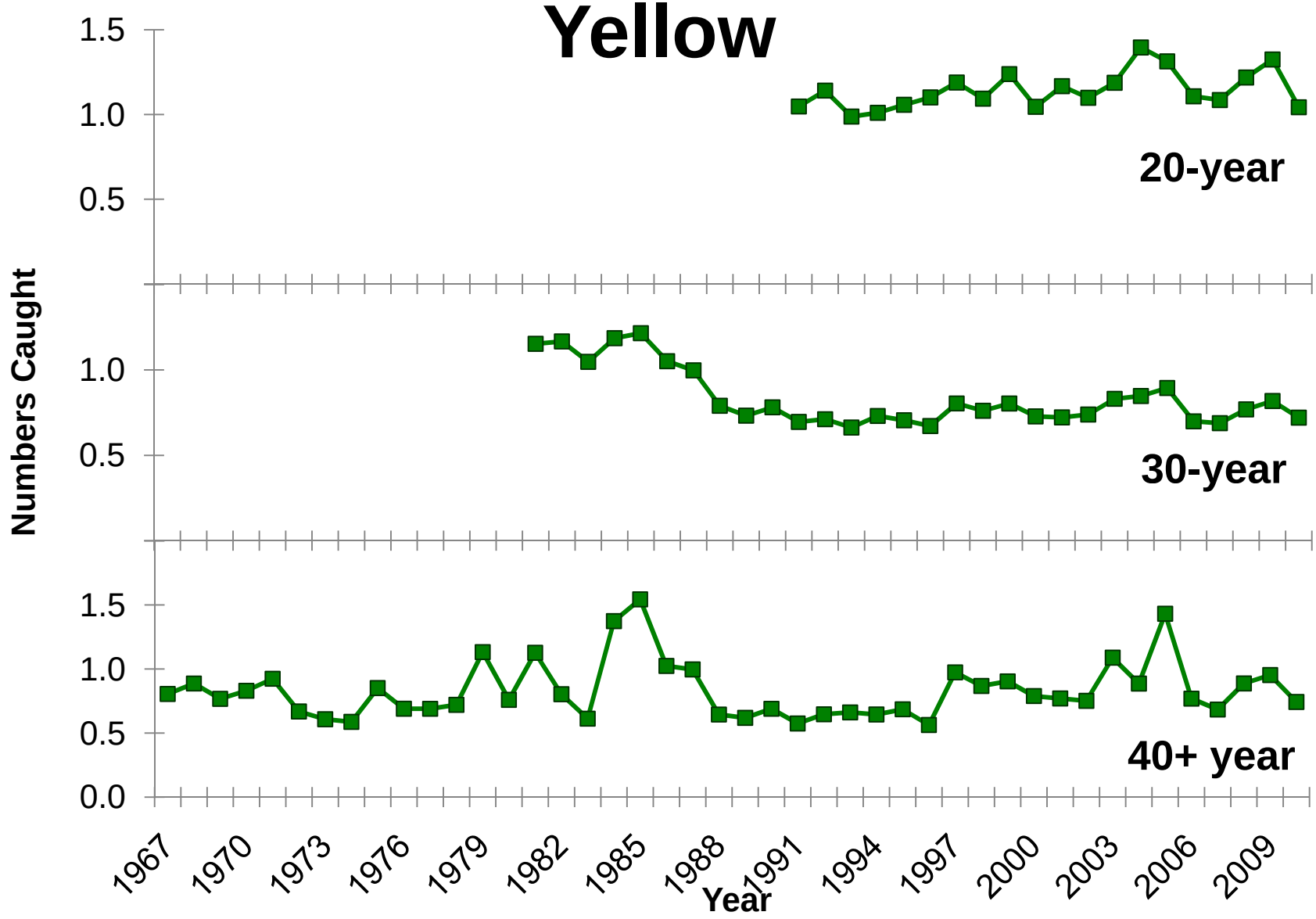
- Individual, local indices combined using GLM
- Indices of YOY and yellow-stage abundance

Coast-wide Indices
YOY—Long-term



Coast-wide Indices

Yellow



Analyses

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- Trend analyses
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Analyses

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- Growth modeling
- **Trend analyses**
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Trend Analyses

- Three approaches
  - Mann-Kendall test
  - Manly meta-analysis
  - Autoregressive Integrated Moving Average (ARIMA) model
- All three methods detected significant downward trends in numerous indices over the time period examined

Trend Analyses

- Mann-Kendall test detected a significant downward trend in the 30-year yellow-phase abundance index
- Manly meta-analysis found a consensus for a decline in YOY and yellow eel through time
- Both the ARIMA and Mann-Kendall analyses identified decreasing trends in the Hudson River and South Atlantic regions
- In contrast, survey indices from the Chesapeake Bay and Delaware Bay/Mid-Atlantic Coastal Bays regions showed no consistent increasing or decreasing trends

Trend Analyses

- Trend analyses found evidence of declining or, at least, neutral abundance of American eel in the U.S in recent decades

Analyses

- Index standardization
- Regional & coast-wide indices
- Growth modeling
- Trend analyses
- **Depletion-Based Stock Reduction Analysis (DB-SRA)**

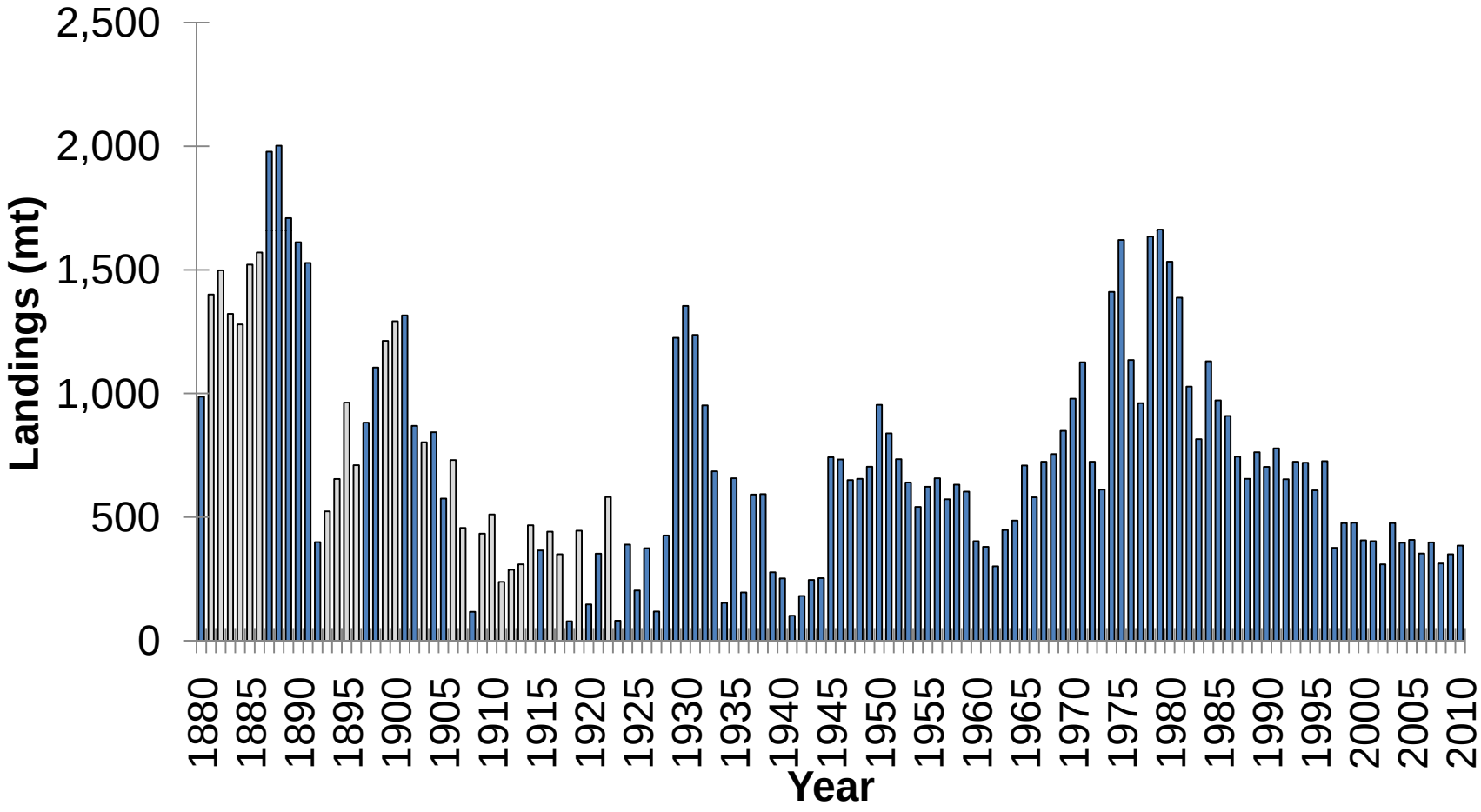
DB-SRA

- Developed on the west coast
- Data-poor production model
- Minimal data requirements
- Provides MSY-based reference points
- *How large must have population been to produce observed catches*?
- Major assumption: Biomass in year 1 of time series = *K*

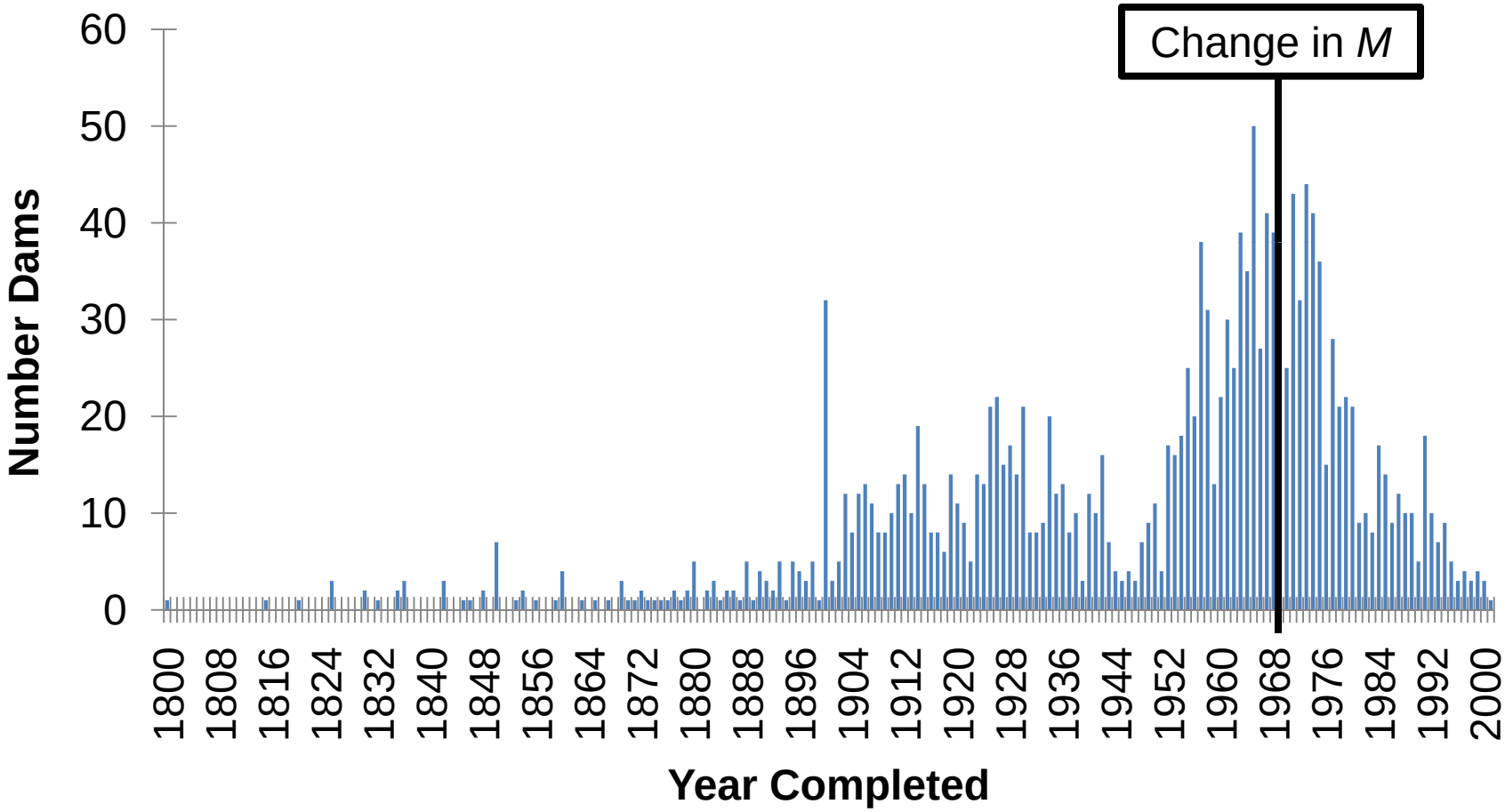
DB-SRA
Eel Model

- Age at maturity: 8
- Time series of catch: 1880–2010
- Incorporates loss of habitat due to dam construction
  - Change in *M* between 1969 and 1970
- Note: Results conditional on input assumptions

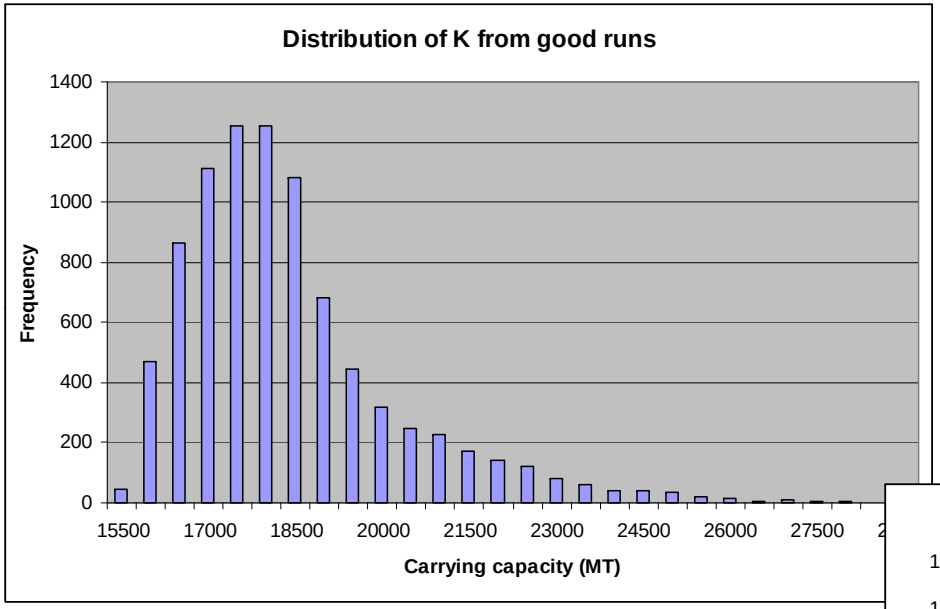
DB-SRA
Eel Model—Catch Data

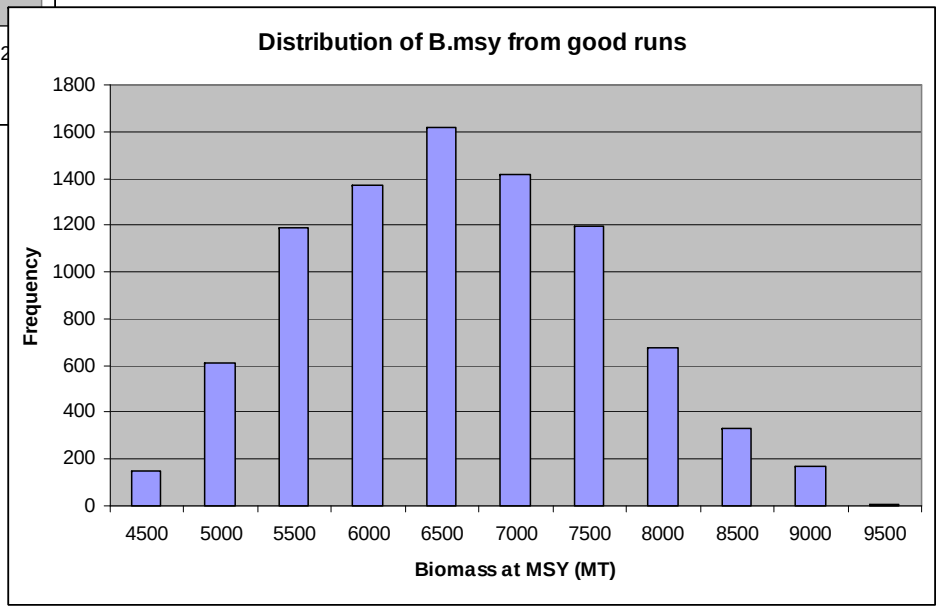


DB-SRA
Eel Model



DB-SRA
Eel Model—Results





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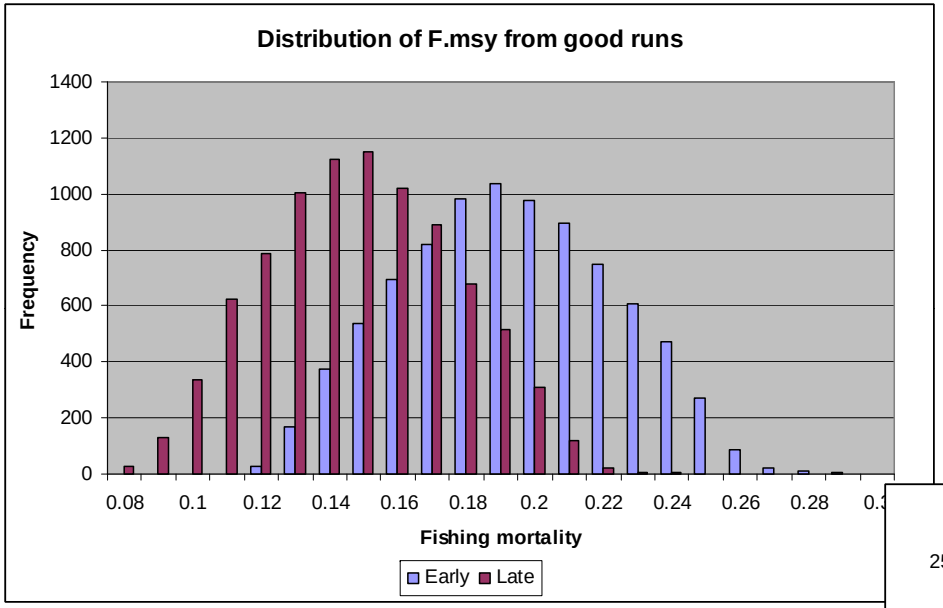

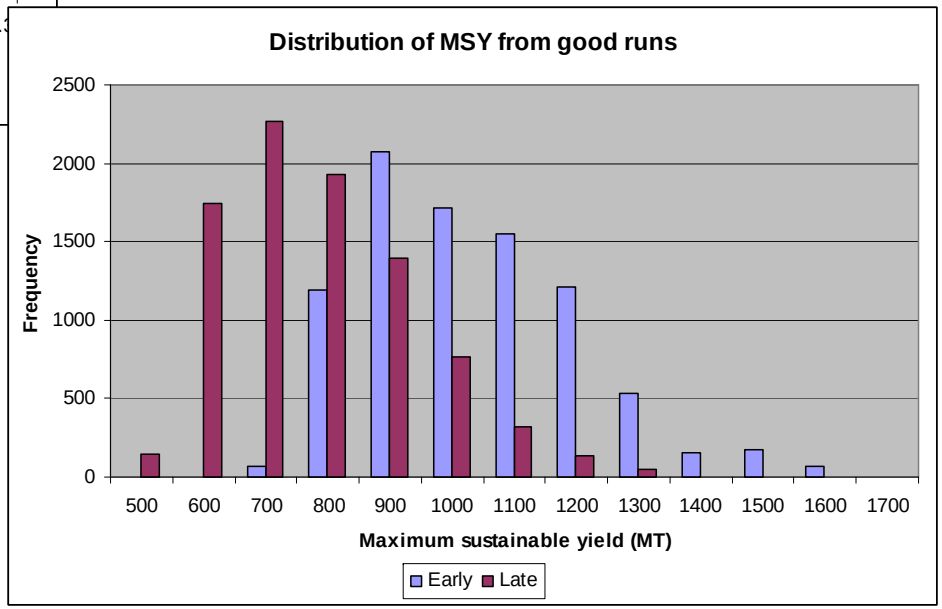

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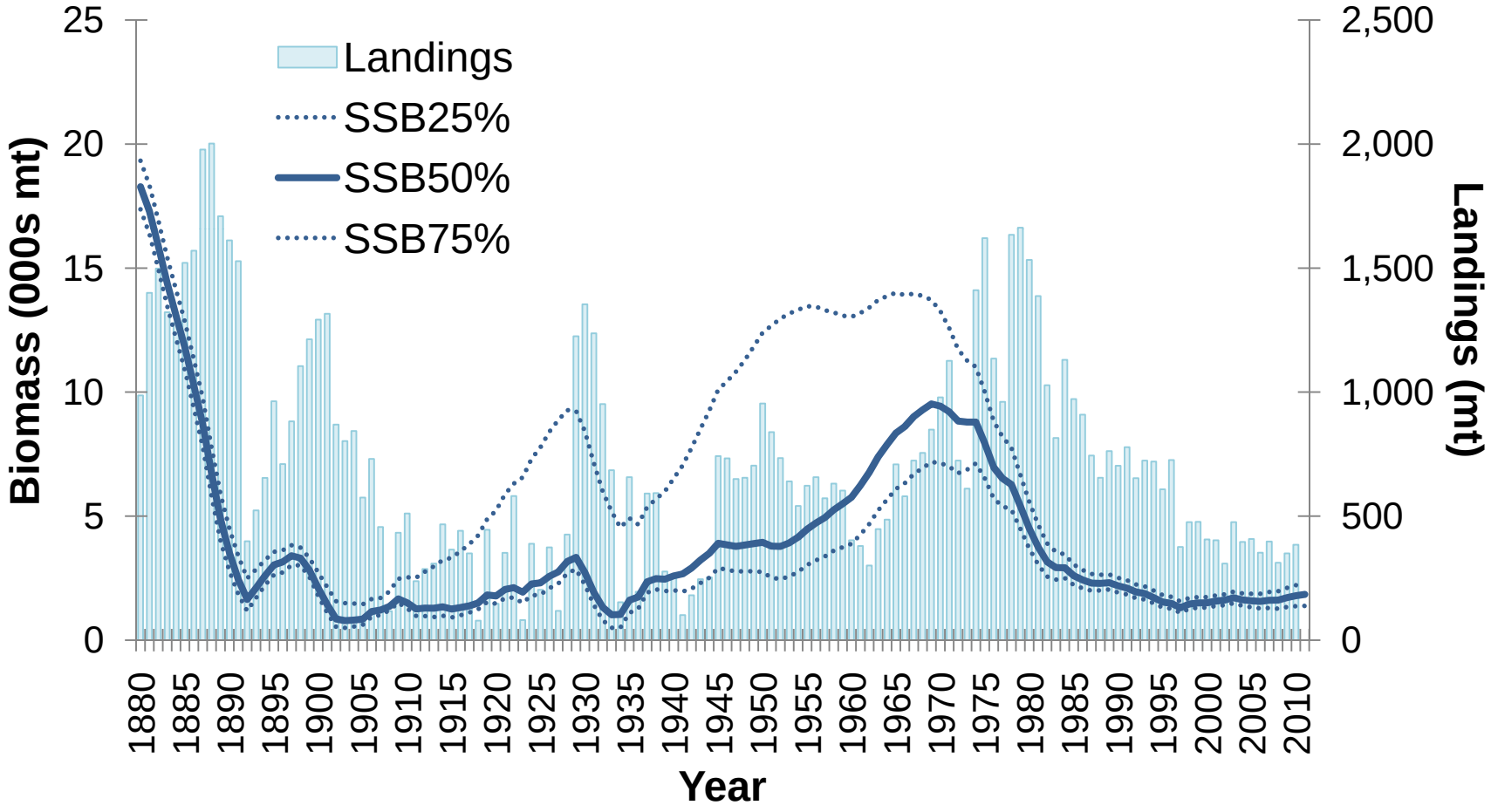

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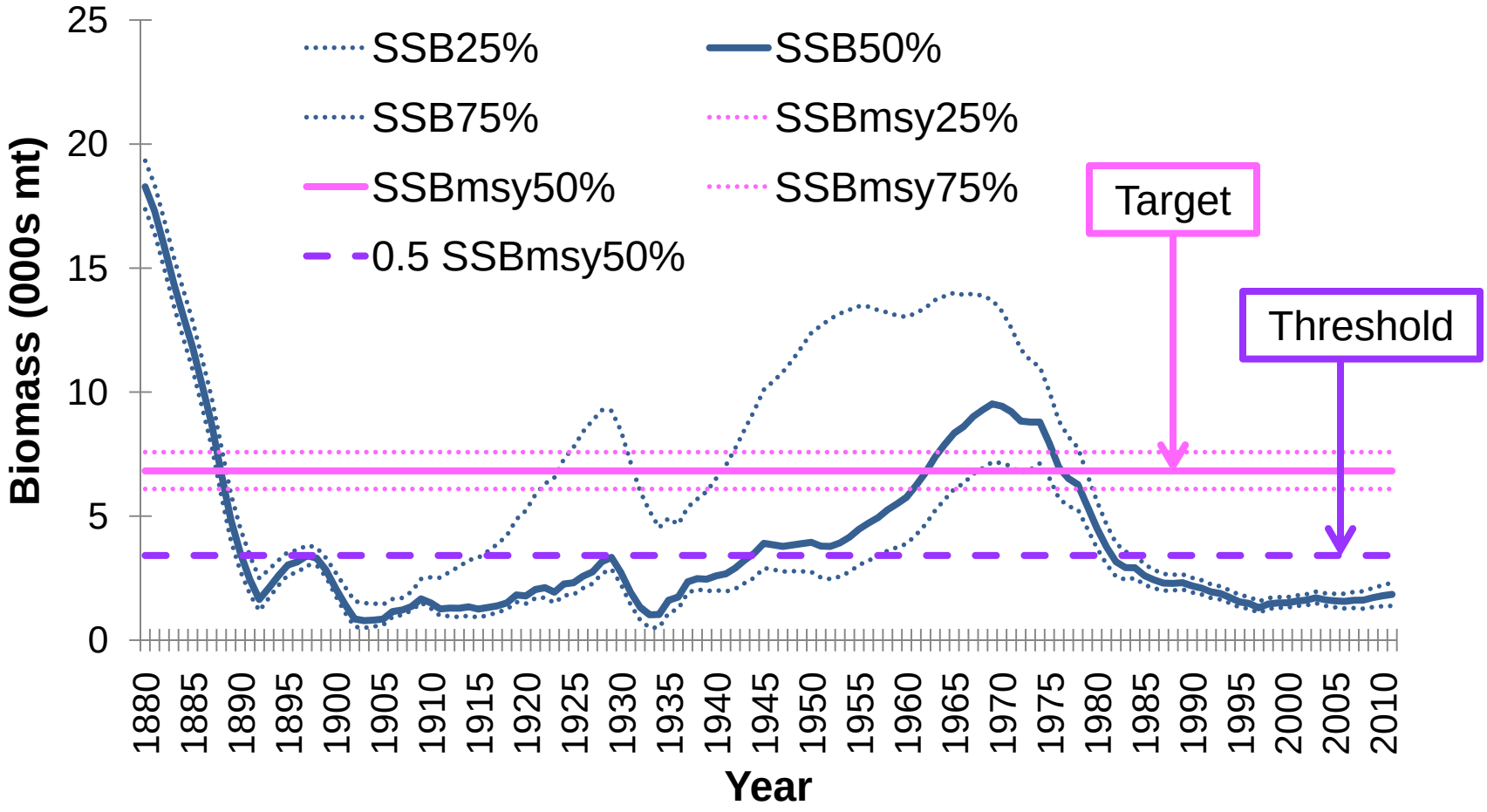

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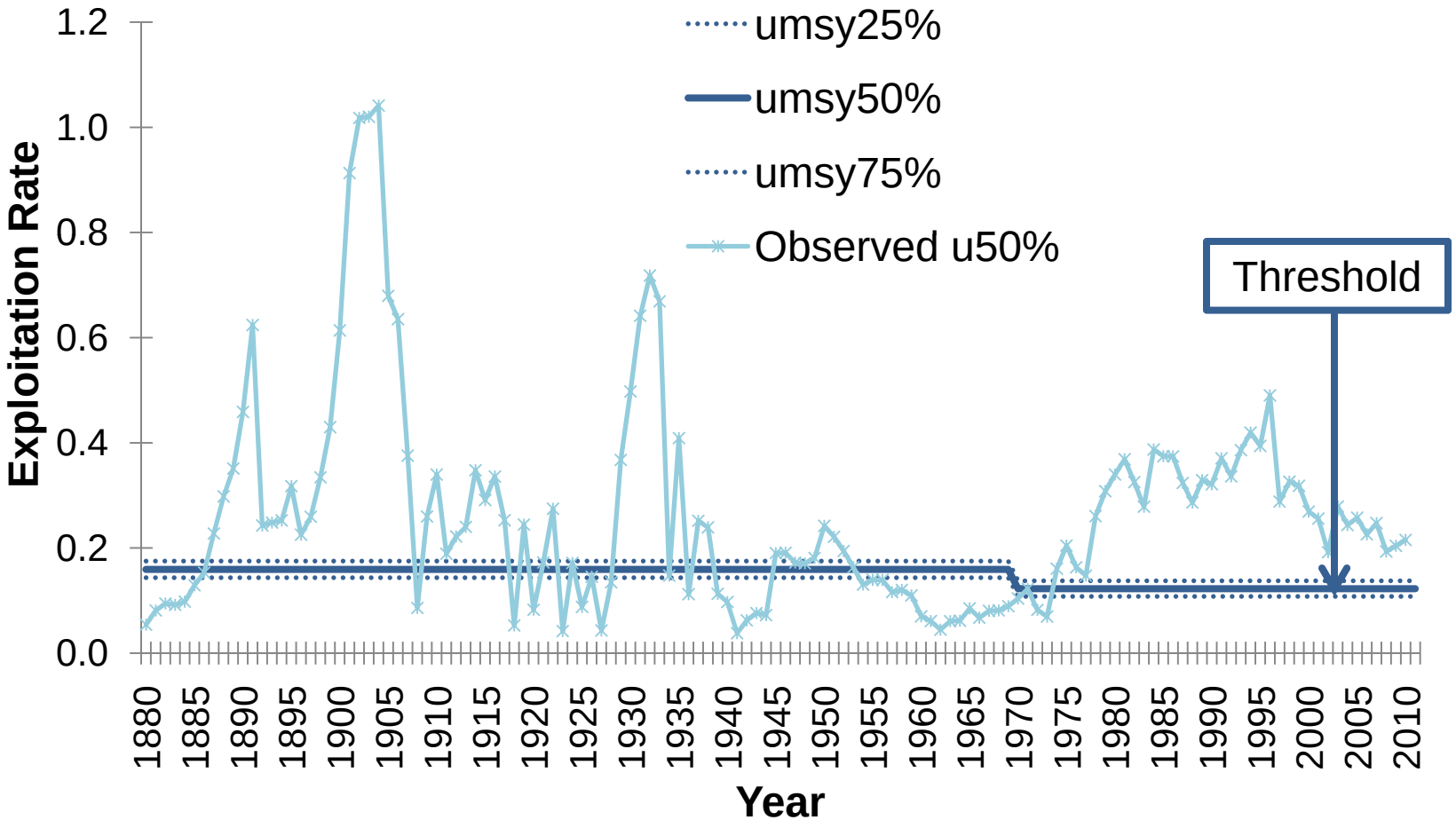

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Stock Status

- DB-SRA
  - Stock is overfished
  - Overfishing is occurring
- *However*, multiple sources of mortality have contributed to reduced biomass…

Stock Status

- Contributors include, but not limited to
  - Substantial harvest in the 1970s
  - Loss of habitat
  - Predation
  - Environmental & climatological factors
- “Depleted” is more accurate description of stock status

Discussion

- Assessment complex
  - Life history
  - Data limitations
  - Portion of range
- Evidence for declining or neutral trends in recent decades
  - Supported by trend analyses and DB-SRA
  - Consistent with results of ICES 2001 assessment
  - Supported by literature

Discussion

- Reduction in mortality warranted
- Need for international coordination of management
- Joint assessment with Canada would be beneficial

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Research Recommendations

- Improve accuracy of commercial catch and effort data
- Characterize the length, weight, age, and sex structure of commercial harvest over time
- Improve understanding of the distribution and frequency of occurrence over time

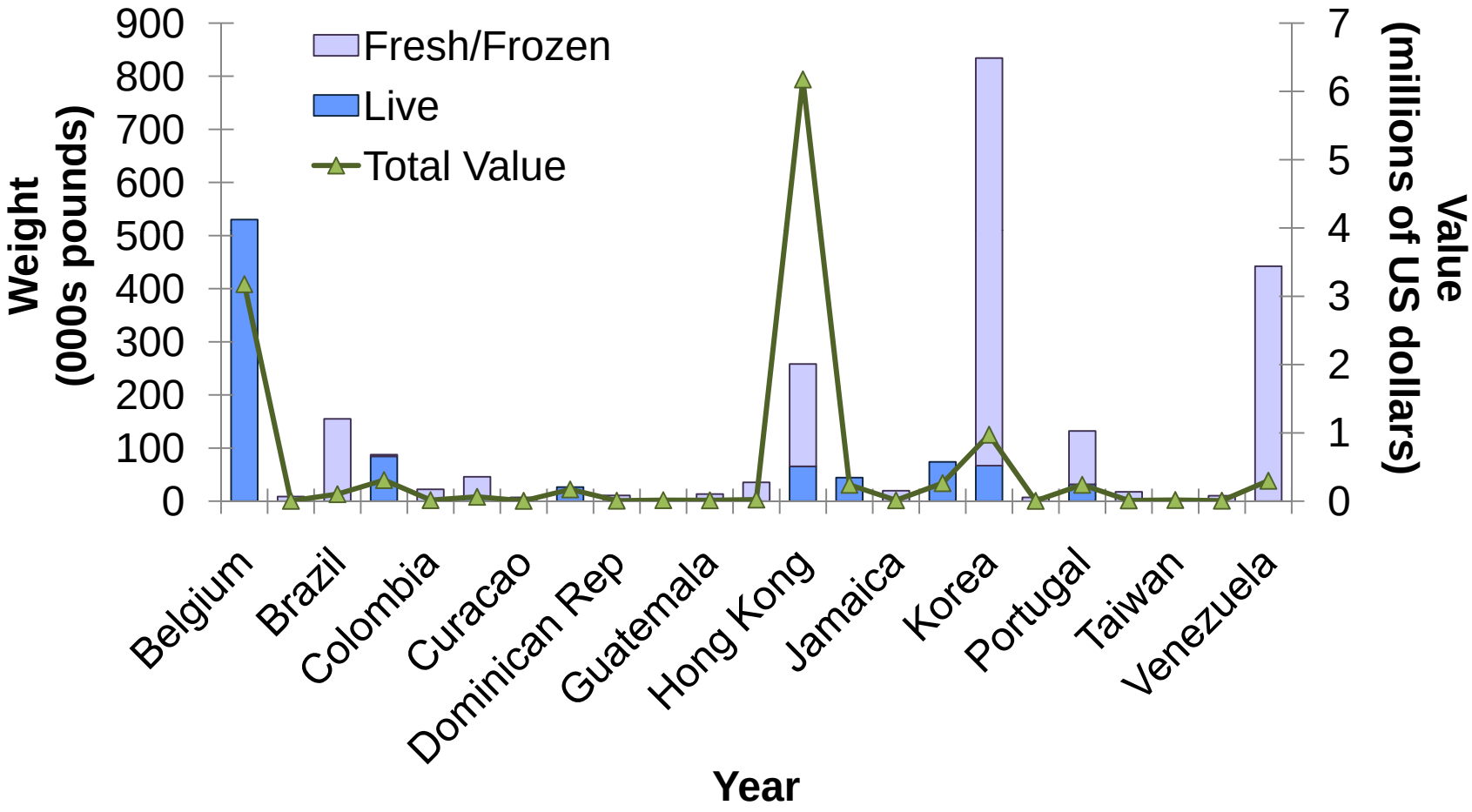
Research Recommendations

- Improve understanding of impact of *Anguillicoloides crassus* on American eel
- Improve understanding of spawning and maturation
- Improve upstream and downstream passage for all life stages
- Improve understanding of habitat needs and availability

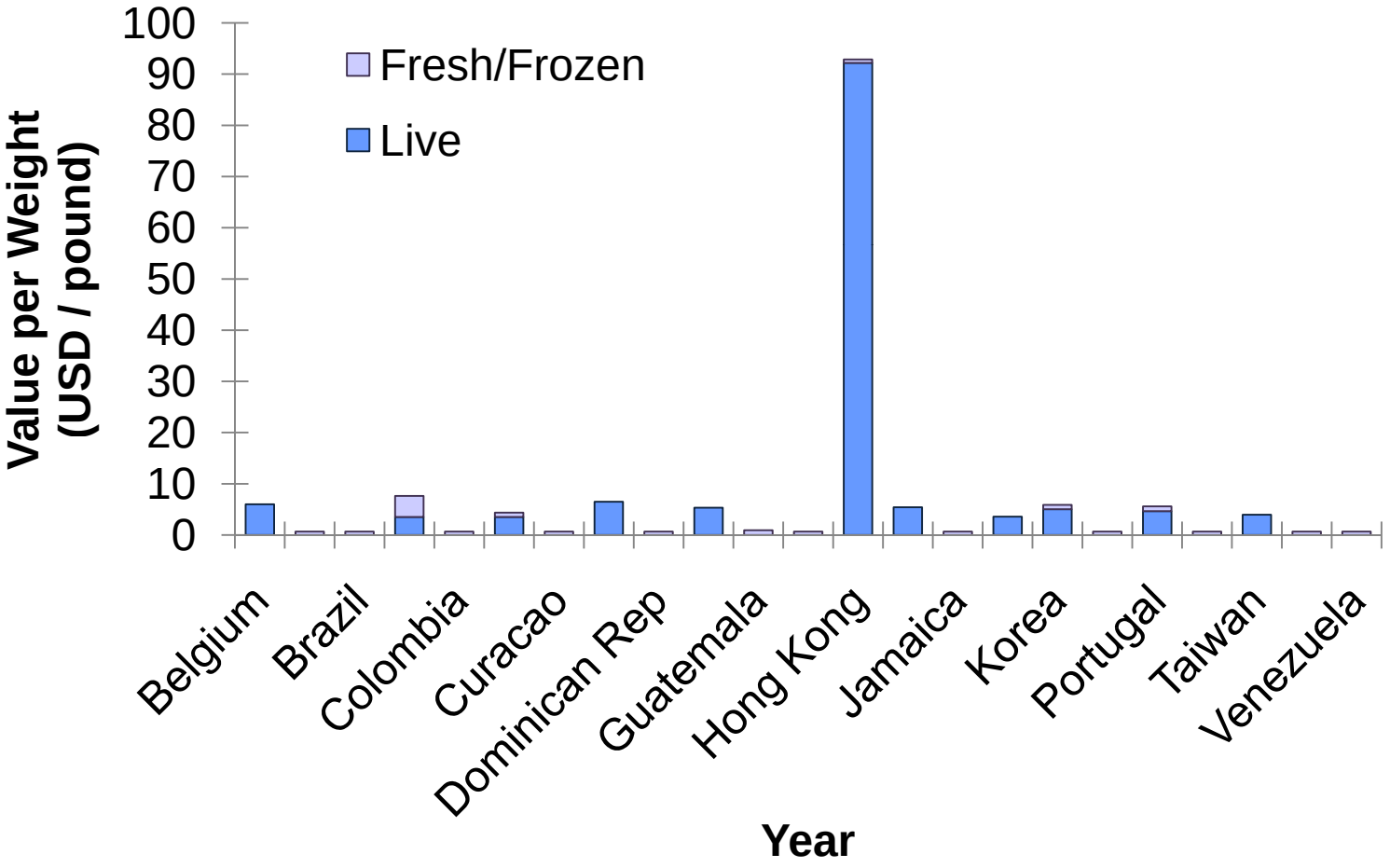
Research Recommendations

- Conduct intensive age and growth studies at regional index sites to support development of reference points and estimates of exploitation

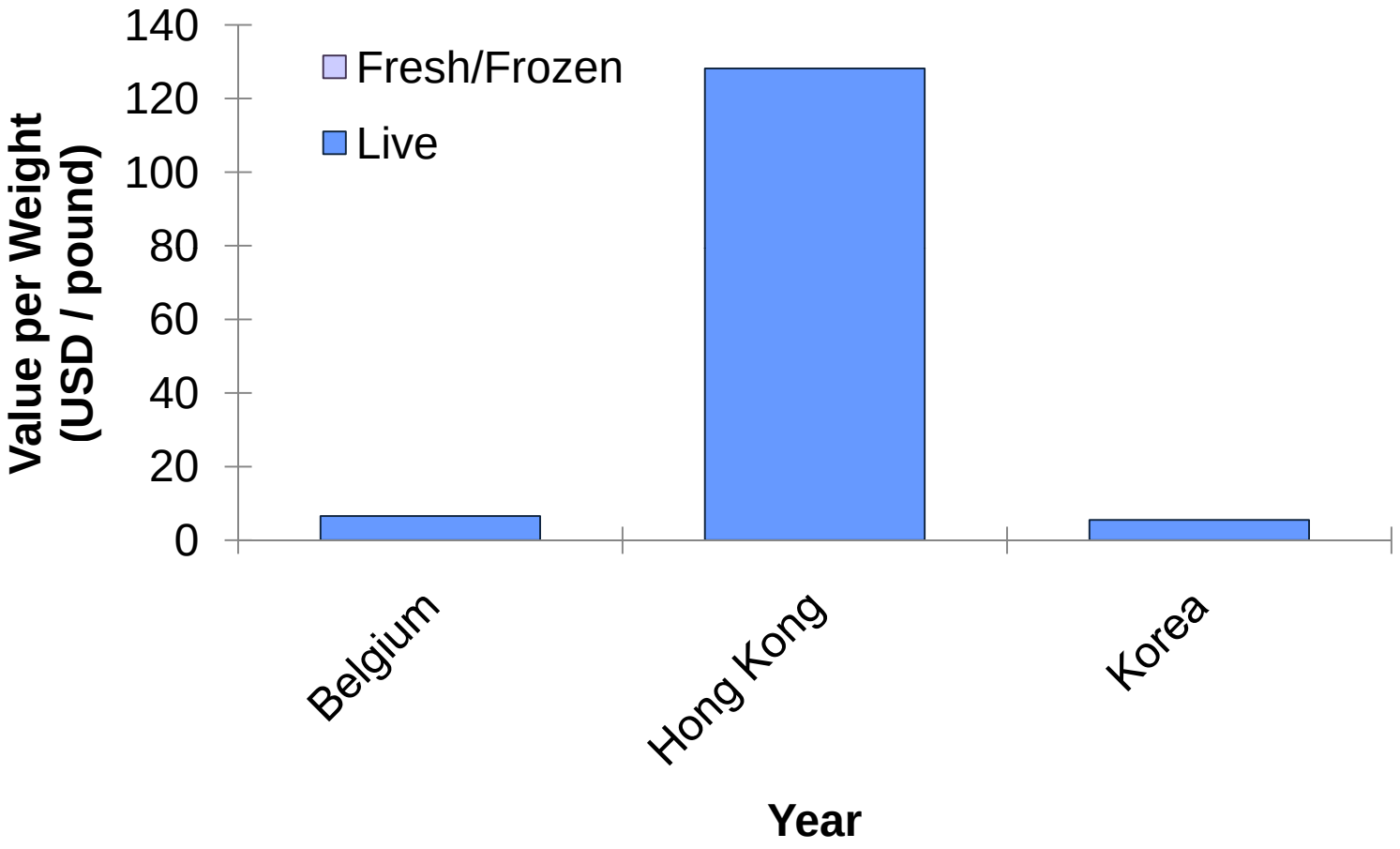
Exports—2011



Exports—2011



Exports—2012



Recreational Fishery

Harvest (Numbers)							
	MRFSS			MRIP			
Year	Estimate	PSE		Estimate	PSE		Difference
2004	23,129	37.0		41,286	61.4		18,157
2005	8,362	49.7		5,217	48.4		-3,145
2006	19,717	44.2		19,389	53.5		-328
2007	57,986	56.9		40,676	60.1		-17,310
2008	3,485	53.5		3,062	46.0		-423
2009	6,213	46.4		9,890	57.5		3,677
2010	60,202	67.7		129,803	78.7		69,601

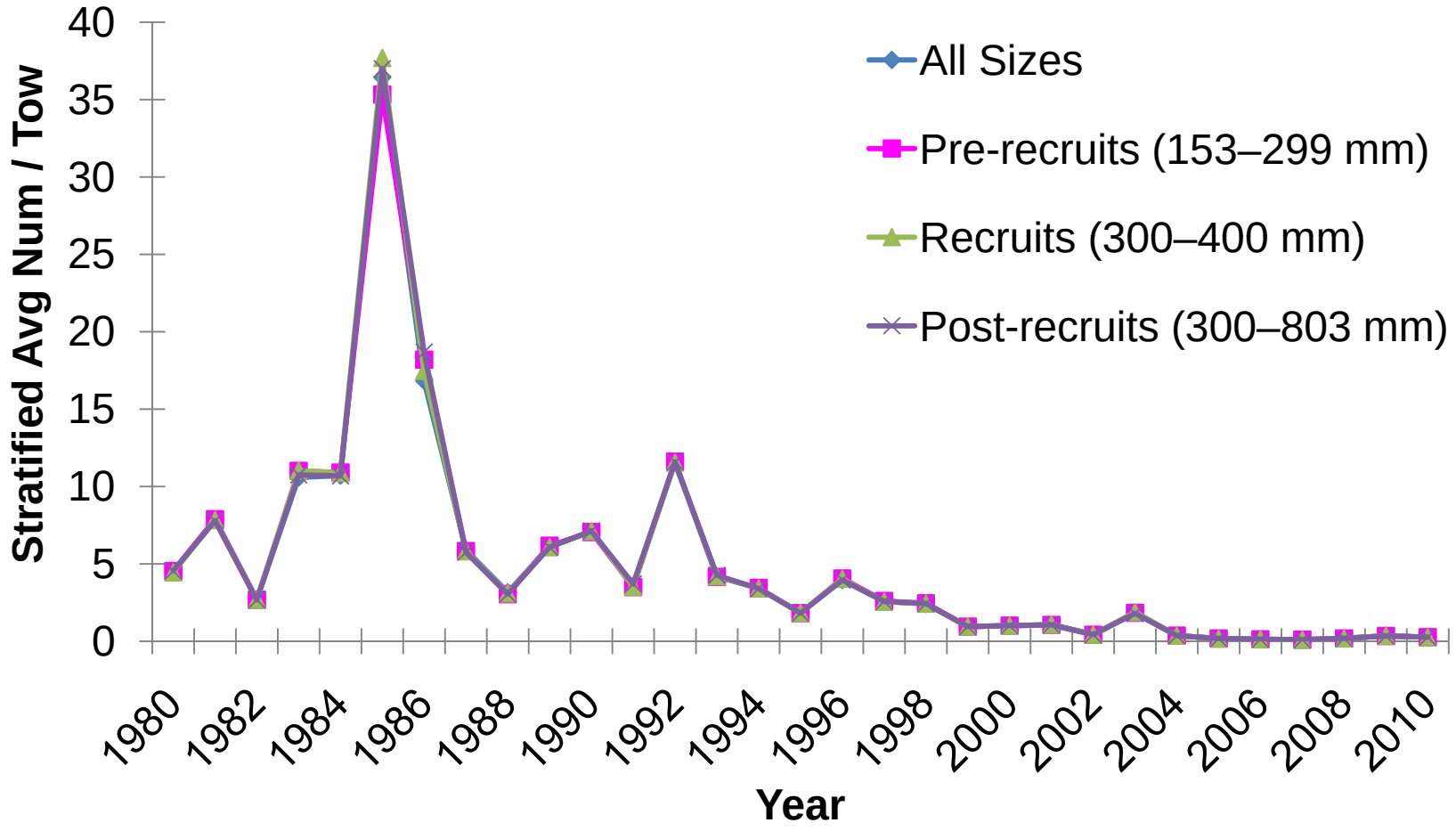
Recreational Fishery

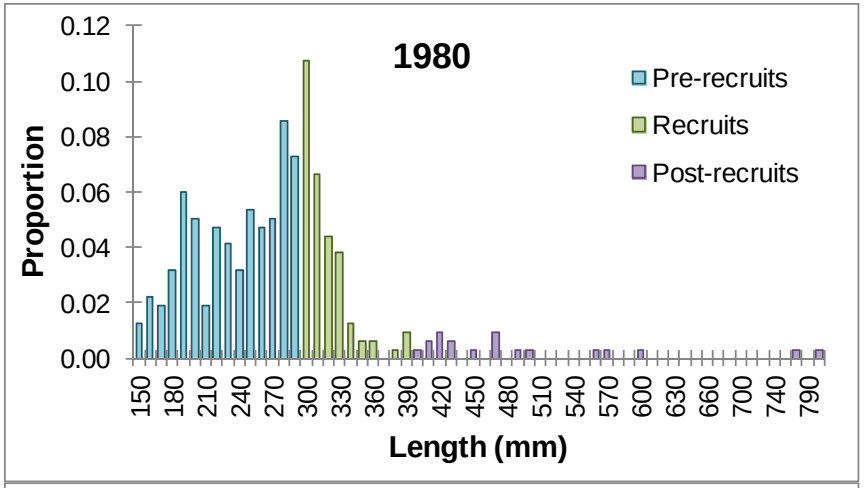
Harvest (Weight)							
	MRFSS			MRIP			
Year	Estimate	PSE		Estimate	PSE		Difference
2004	13,411	55.9		41,468	64.7		28,057
2005	2,469	98.3		4,515	51.7		2,046
2006	11,043	45.2		16,478	49.0		5,435
2007	49,068	76.8		60,500	70.6		11,432
2008	353	100.1		1,334	58.6		981
2009	5,600	32.4		6,074	60.3		474
2010	25,922	87.3		25,055	62.5		-867

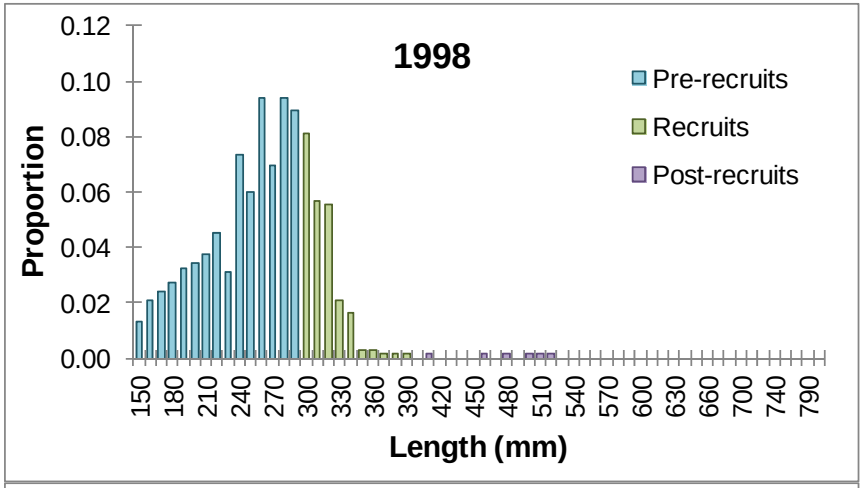
Recreational Fishery

Released Alive (Numbers)							
	MRFSS			MRIP			
Year	Estimate	PSE		Estimate	PSE		Difference
2004	90,829	24.8		74,653	24.5		-16,176
2005	50,702	21.2		63,939	40.8		13,237
2006	66,307	24.5		99,974	42.1		33,667
2007	82,385	26.6		113,424	47.3		31,039
2008	45,323	23.0		62,625	34.5		17,302
2009	56,522	20.0		92,399	31.3		35,877
2010	75,102	25.3		90,437	28.6		15,335

Evaluation of Data
VIMS Trawl Survey




1980
Pre-recruits
Recruits
Post-recruits
Proportion
0.12
0.10
0.08
0.06
0.04
0.02
0.00
150 180 210 240 270 300 330 360 390 420 450 480 510 540 570 600 630 660 700 740 790
Length (mm)


1998
Pre-recruits
Recruits
Post-recruits
Proportion
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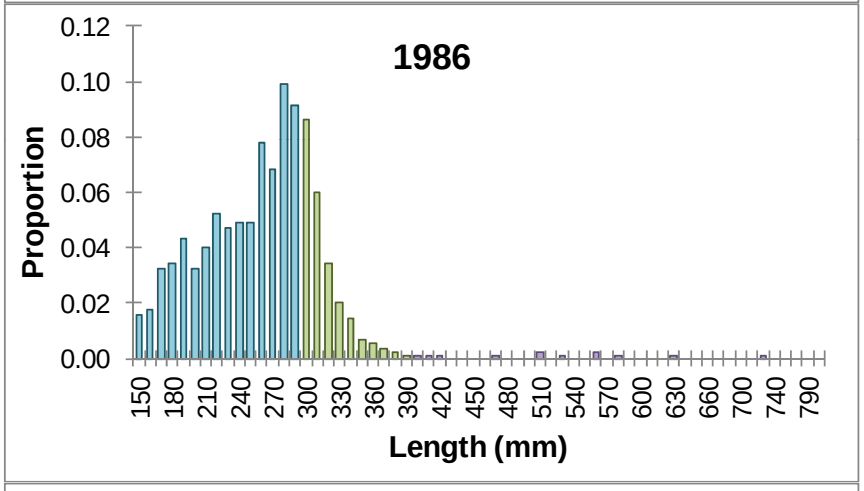
Length (mm)


1986
Proportion
0.12
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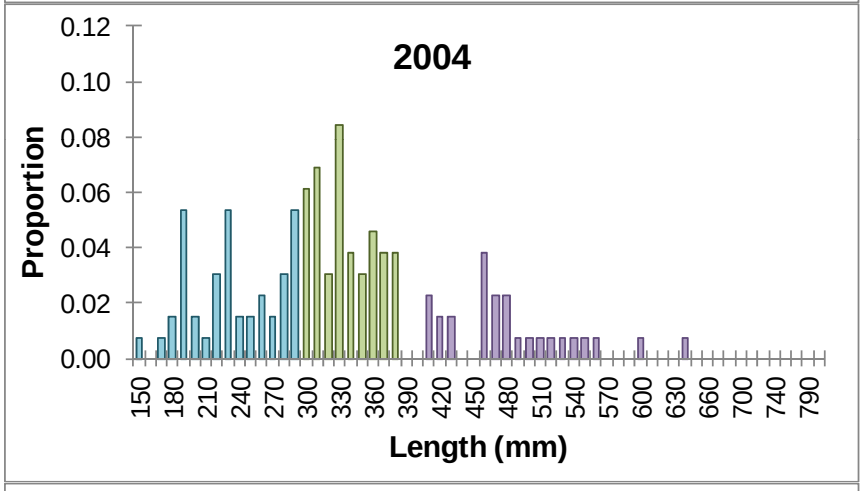
Length (mm)


2004
Proportion
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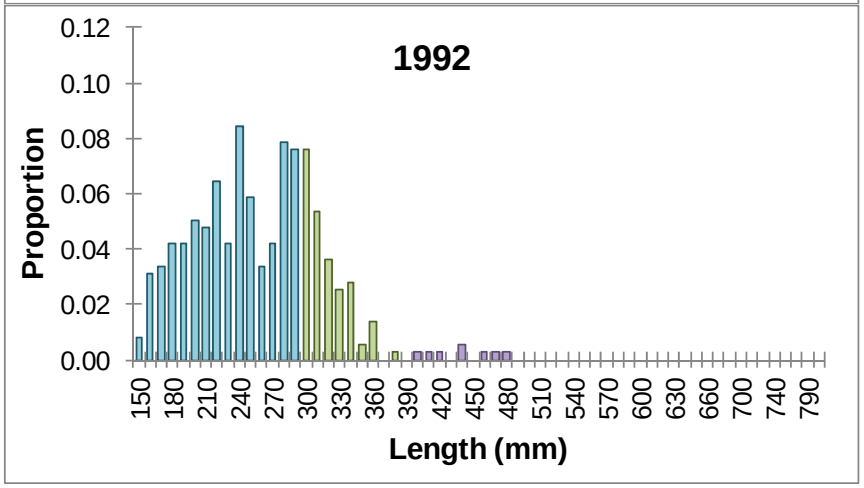
150 180 210 240 270 300 330 360 390 420 450 480 510 540 570 600 630 660 700 740 790
Length (mm)


1992
Proportion
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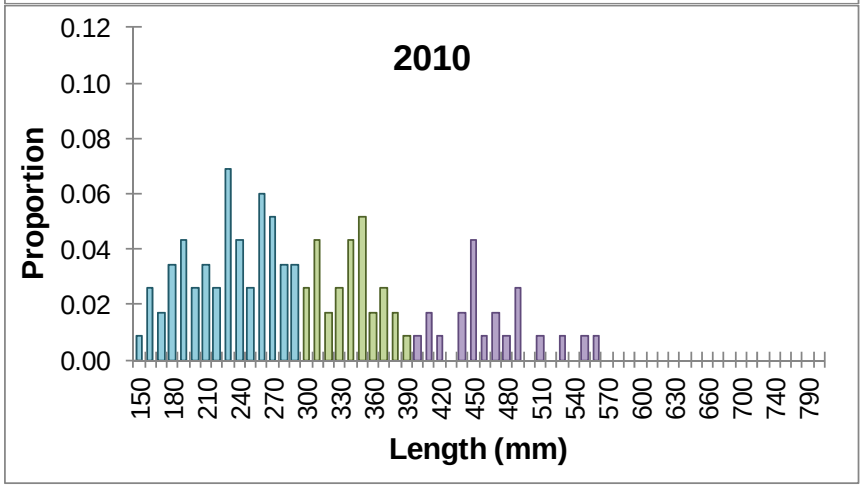
150 180 210 240 270 300 330 360 390 420 450 480 510 540 570 600 630 660 700 740 790
Length (mm)


2010
Proportion
0.12
0.10
0.08
0.06
0.04
0.02
0.00
150 180 210 240 270 300 330 360 390 420 450 480 510 540 570 600 630 660 700 740 790
Length (mm)

DB-SRA
Eel Model—Development

Parameter	Distribution	Min	Max
M_{early}	Uniform	0.15	0.25
M_{late}	Uniform	$1.15*M_{early}$	$1.30*M_{early}$
F-Ratio$_{early}$	na	$(Z_{MSY} - M_{early}) / M_{early}$	
F-Ratio$_{late}$	na	$(Z_{MSY} - M_{late}) / M_{late}$	
B_{mnpl}	Uniform	0.25	0.50
B-Ratio	Uniform	0.05	0.15
Z_{MSY}	Uniform	$1.8*M_{early}$	$2.2*M_{early}$

Working towards healthy, self-sustaining populations for all Atlantic coast fish species or successful restoration well in progress by 2015

Photo: David Doubillet, National Geographic

American Eel

Peer Review Report

The Peer Review Team:

Karin E. Limburg, SUNY-ESF (chair)

Robert O'Boyle, Beta Scientific Cons.

Ken Oliveira, U. Mass. Dartmouth

John Weidemann, Rutgers U.

Terms of Reference

- Evaluate/assess data collection and analysis
- Evaluate models used
- Evaluate diagnostics/uncertainty analysis
- Evaluate stock status, reference points
- Make recommendations

Data collection and analysis

- SASC cast a wide net for fishery independent and dependent data sets
- Did a commendable job to summarize biology – many really good coastwide comparisons
- VIMS longterm trawl data would be extremely helpful to obtain

Data and trend analysis

- As previously recommended, SASC performed uncertainty and trend analyses
- Used General Linearized Models (GLM) to standardize data sets – coastwide model produced from these probably understates variance
- Juvenile trend analyses hampered to some extent by brevity of data series

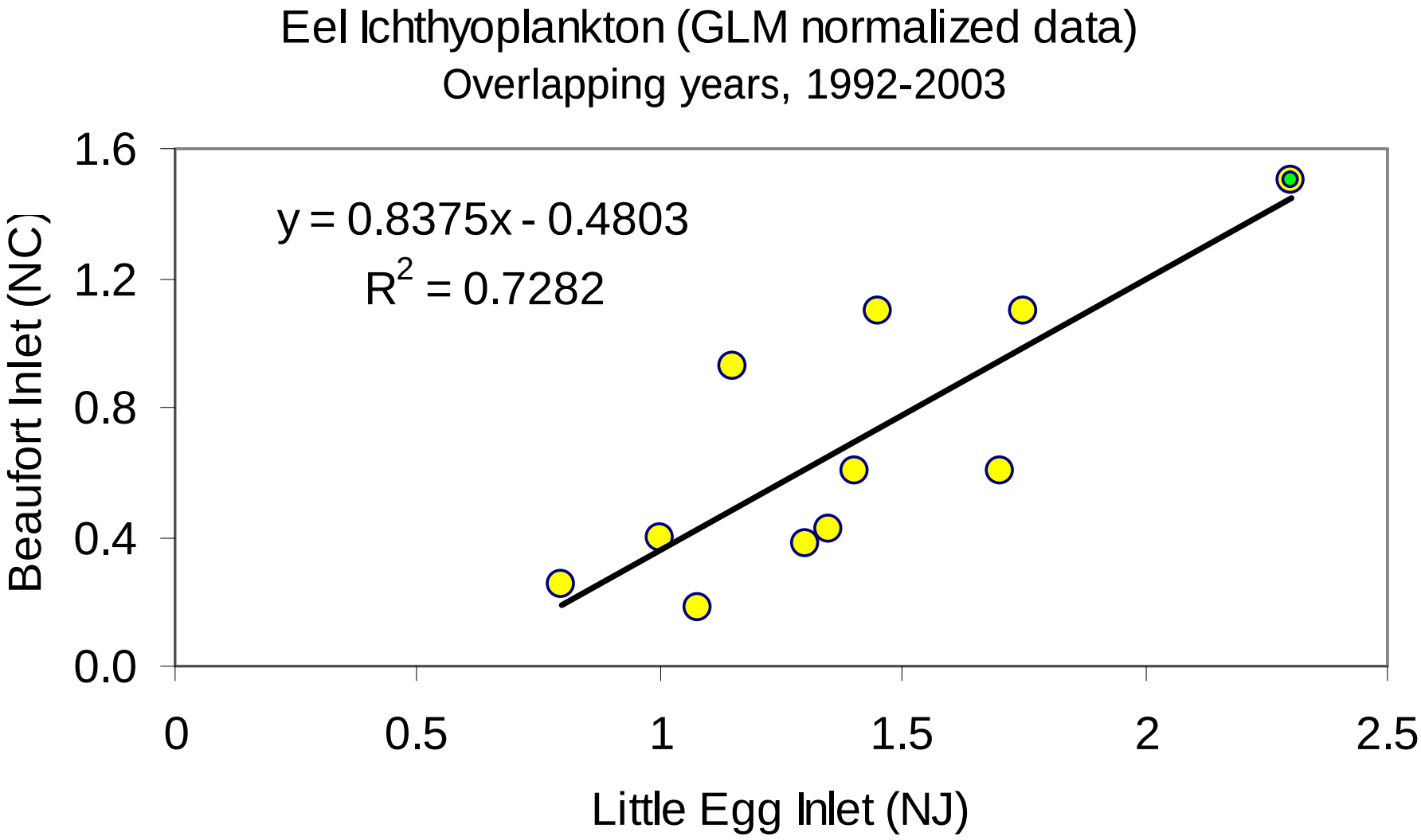


Figure 1. Regression of eel leptocephali indices from Beaufort Inlet, NC on Little Egg Inlet, NJ. The high leverage point consists of two superimposed points.

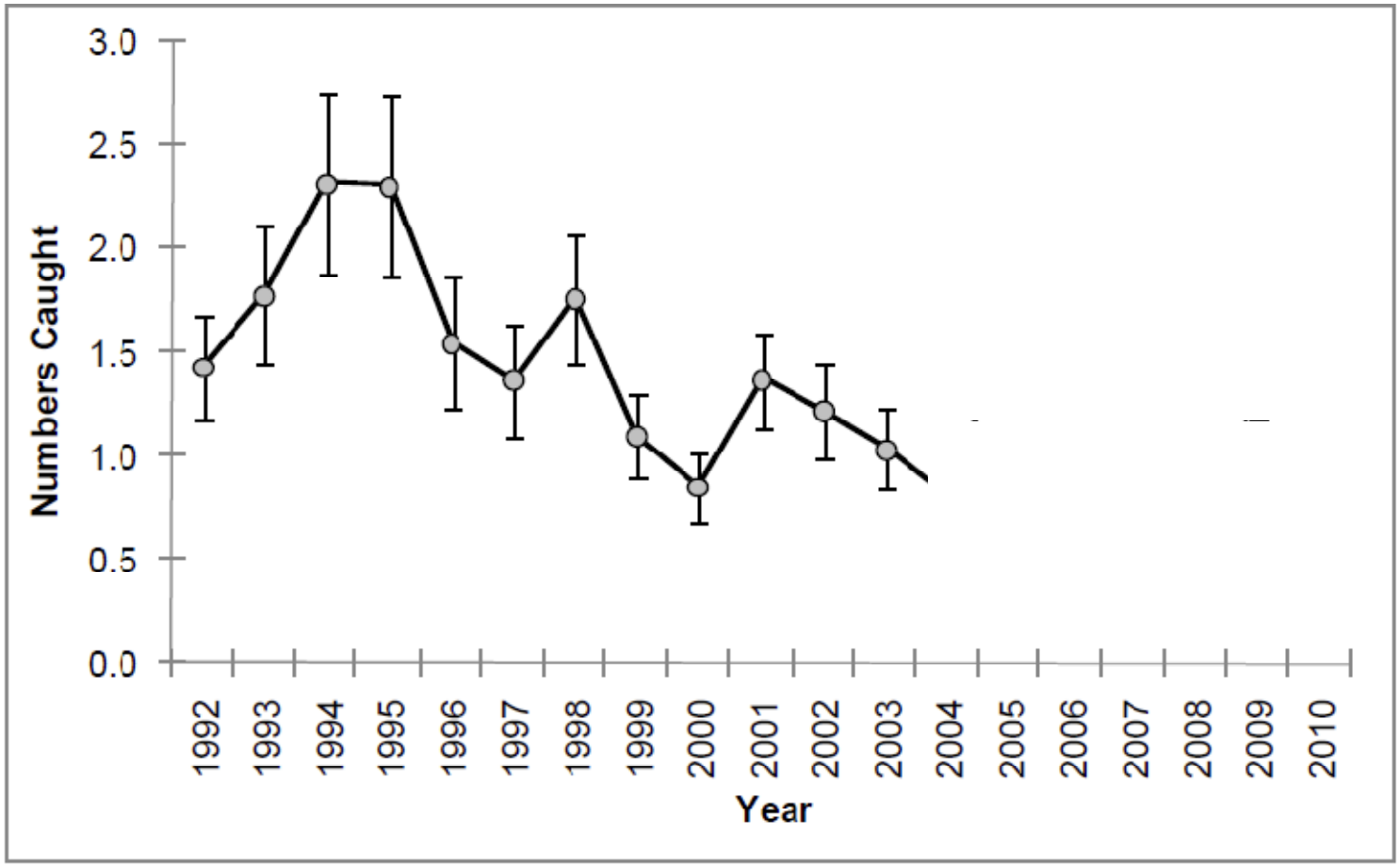


Figure 5.35. GLM-standardized index of abundance for YOY American eels caught by the Little Egg Inlet Ichthyoplankton Survey, 1992–2010. The error bars represent the standard errors about the estimates.

Data and trend analysis, cont'd.

- ARIMA, Mann-Kendall tests, power analyses, meta-analyses
- "Traffic Light Approach"

Photo: David Doubillet, National Geographic

Assessment models

SASC considered a number of different population assessment models – really "did their homework"

Found most models inappropriate or could not be used due to lack of input data

Eventually selected ***Depletion-Based Stock Reduction Analysis*** (DB-SRA) – appropriate to data-poor situations

DB-SRA pro's and con's

Pro's:

- Can be used with inputs based on expert judgement
- Innovated a way to estimate an input ($B_{current/K}$)
- Innovated a change in "natural" mortality (M) by upping it in 1970 to reflect dam intensification

Con's:

- model is configured for freshwater /estuarine life stages – no marine consideration
- assumes the stock is "closed" within US; not true
- other assumptions may not be justified (e.g. age at maturity; $B_{current}$/carrying capacity = 10%; and just what is K?)

Evaluate assessments of biomass, abundance, and exploitation

DB-SRA model indicates three periods of heavy exploitation: 1890-1910, 1930-36, and 1978-95

- Unclear what happened to population after 1st two periods of heavy exploitation (Q: was "reservoir" still present?)

- Current exploitation rates unclear b/c of uncertainty of $B_{current}/K$

Evaluate methods/choice of reference points, and stock status

3 sets of reference points were developed:

1. ARIMA of 20-yr yellow eel index: < 25th %-ile with 80% confidence

   - Of limited use: difficult to see how management actions could result from this

Reference points, cont'd.

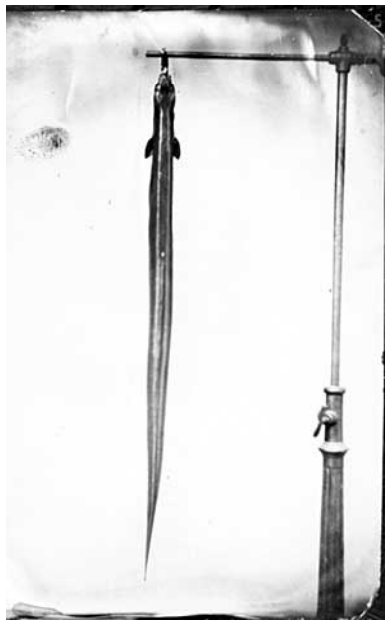
2. "Traffic Light Approach"

- Current results complex, hard to interpret
- However, this approach has utility in data-poor situations and permits including a broad suite of indices (incl. environment)
- Therefore Panel encourages more development of TLA

Turbine mortality.
Photo: D. Watts

Reference points, cont'd.

3. Ref. points based on DB-SRA:



- Model produces estimates (and ranges) of key indices: K, MSY, B_{MSY}, and F_{MSY}
- However, uncertainties did not permit statements to be made w.r.t. these RPs
- Nevertheless, Panel lauds the progress made

Stock status

- Panel agrees with the SASC that the stock status is **depleted**.
- Can't agree that overfishing is the cause – certainty not there

Eel fishing in Baltic Sea.
Photo: D. Doubillet

However, *panel **does** agree that sources of mortality must be reduced*

The New York Times

Netting Tiny Eels and Big Profits

Craig Dilger for The New York Times

Suzanne Smith, left, and John Taylor on Thursday gathered the elvers that they caught in their nets overnight in Pemaquid, Me.

By ABBY GOODNOUGH
Published: March 29, 2012

The next two months will bring sleepless nights and high anxiety — and quite possibly an extraordinary windfall — for a small universe of people in Maine. They are the lucky few with licenses to catch elvers — young, tiny eels that look like cellophane noodles and by some accounts are fetching up to $2,200 per pound this spring.

Recommendations

There are many, but a few highlights:

- Improve accuracy of commercial and recreational catch/effort data
- Improve biological characterization of the catch (L, W, age, sex ratio)
- Continue and expand YOY surveys

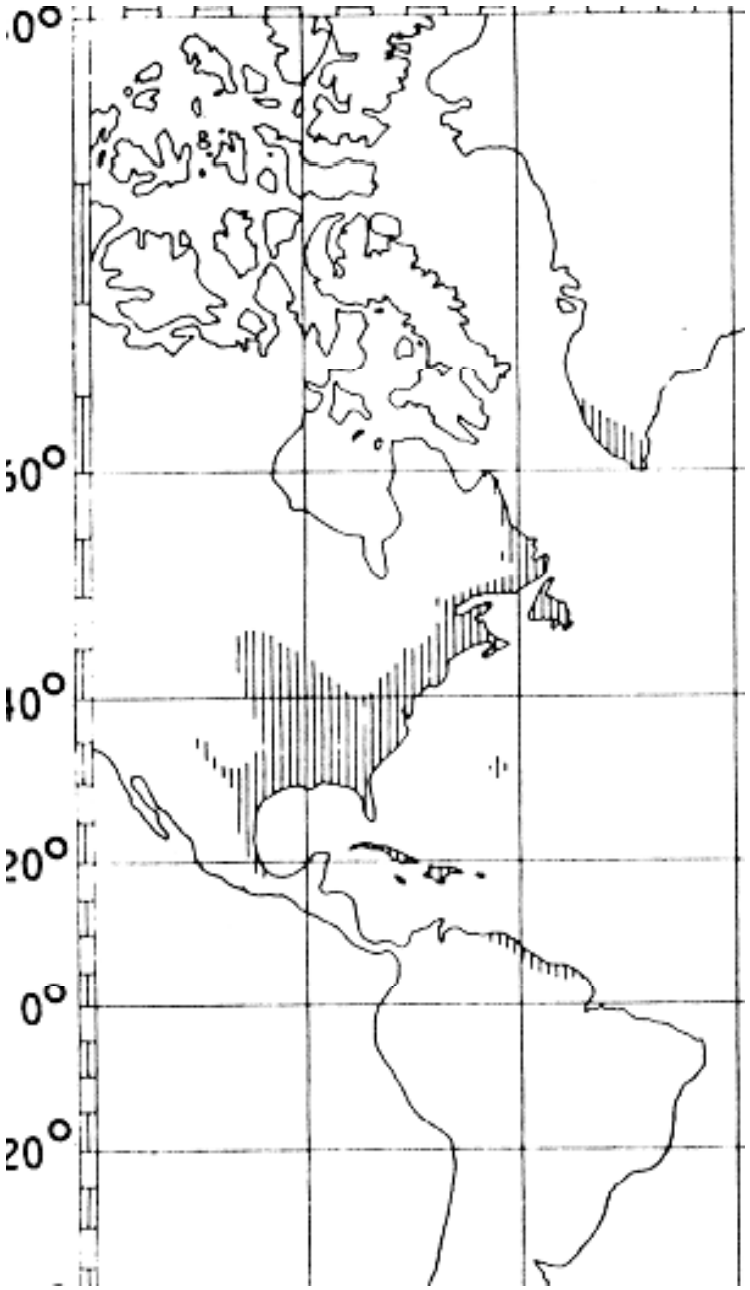
School children participate in glass eel surveys in Hudson River. Photos: NYSDEC

Recommendations, cont'd.

- Expand long term fisheries-independent monitoring, especially in states where it's not done now
- Work with agencies to improve fish passage and reduce dam mortalities
- Work with agencies to improve inland habitat (e.g., reduce pollution)

Recommendations, cont'd.

- Continue to improve models
- Research needs also to address climate change effects (oceanic circulation)
- Work with other nations to conserve American eels – opportunity to plan cooperatively with Canada at next AFS meeting



Tesch, 1977

American eel conservation requires an international cooperative approach

It's a single population!

Conclusions

Panel generally concurs with the Eel SASC that American eel is in decline

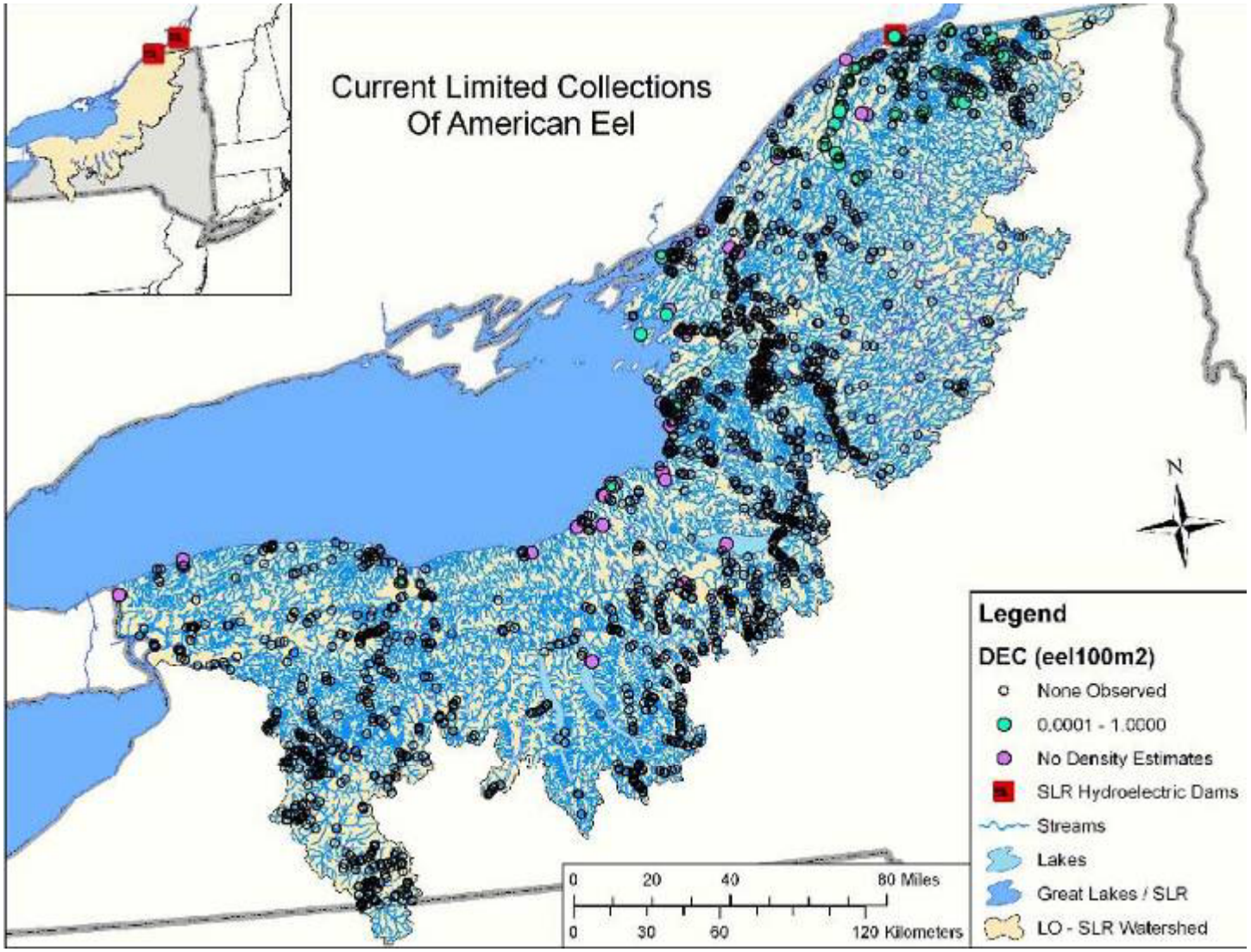
Stock assessment is given a “Pass”

Panel encourages the Eel Technical Committee to continue to work in the directions suggested by the SASC and Panel

Young Eel Clan members of the Onondaga Nation...

...who have never seen a live eel

Photos by Toba Tucker. http://tobatucker.com/gallery/view_album.php?set_albumName=onondaga



Dittman et al. 2006

Measuring a silver eel. Photo: David Yozzo