Southeast United States spiny lobster stock assessment

SEDAR 08
Stock Assessment Panel

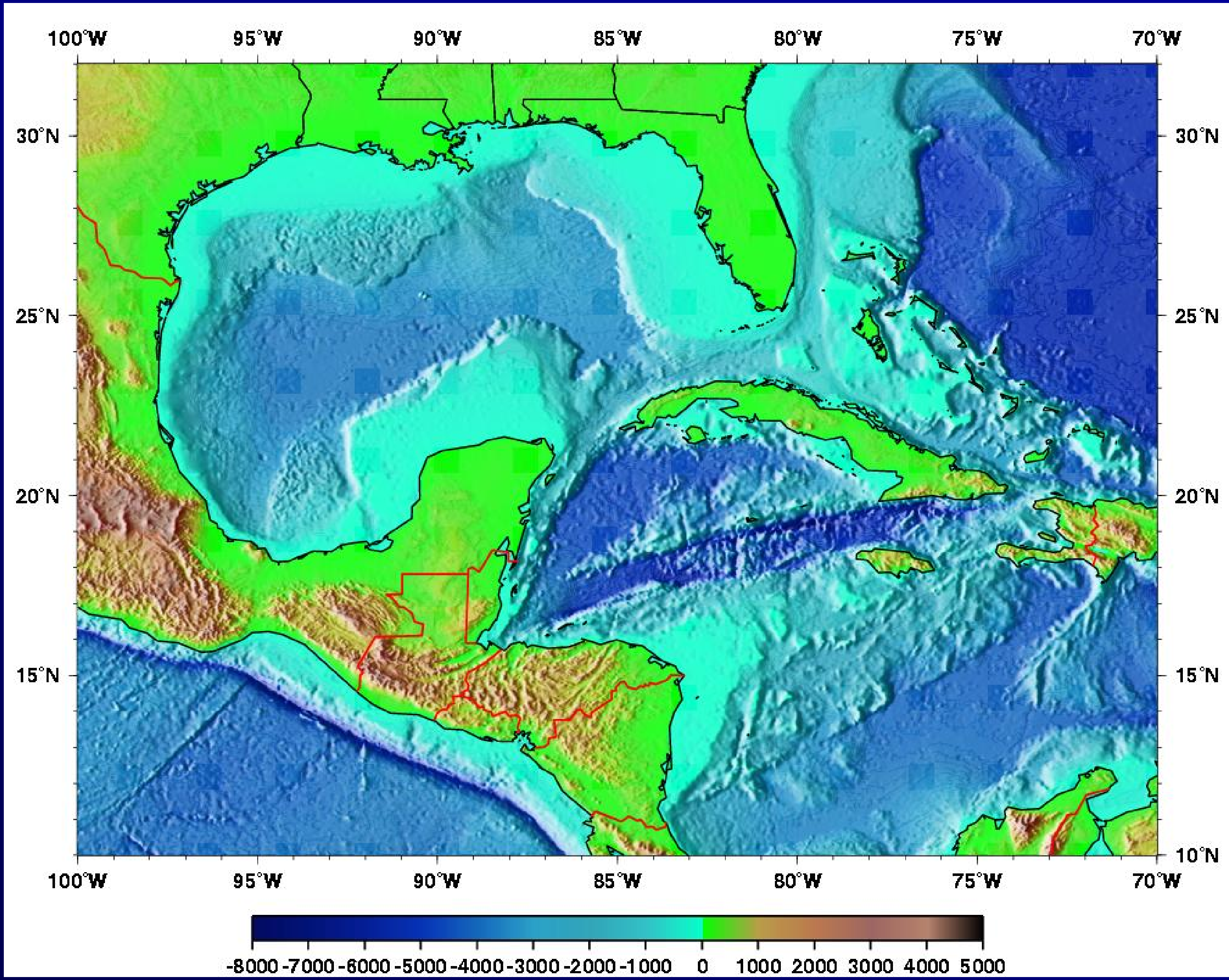
Outline

- Life History
- Landings
- Catch rates
- Assessment models
- Benchmarks
- Status of stock
- Research recommendations

Life History

- Stock Identification
- Habitat
- Growth
- Reproduction

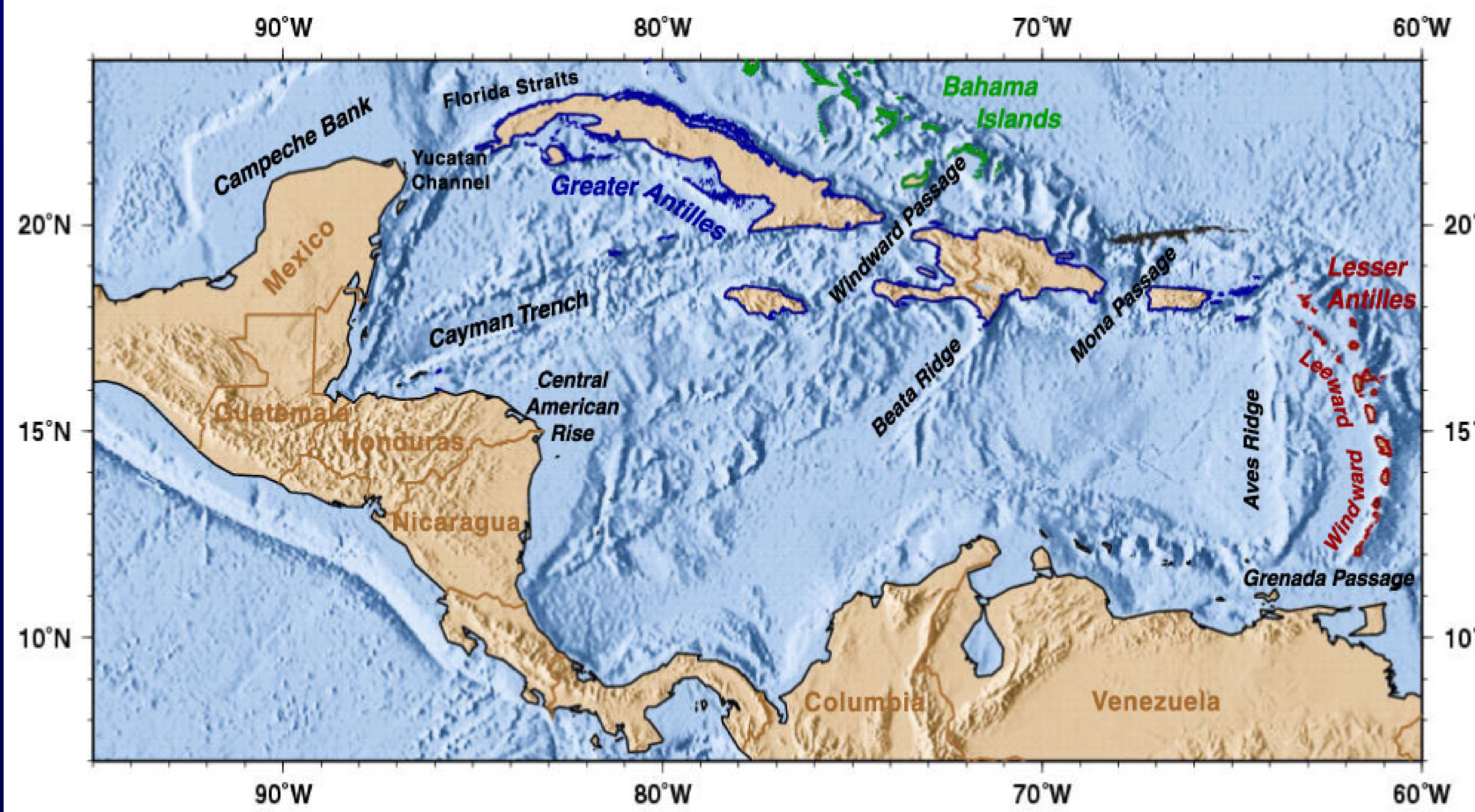
Stock Identification



Gulf of Mexico and western Caribbean basin

RSMAS, University of Miami

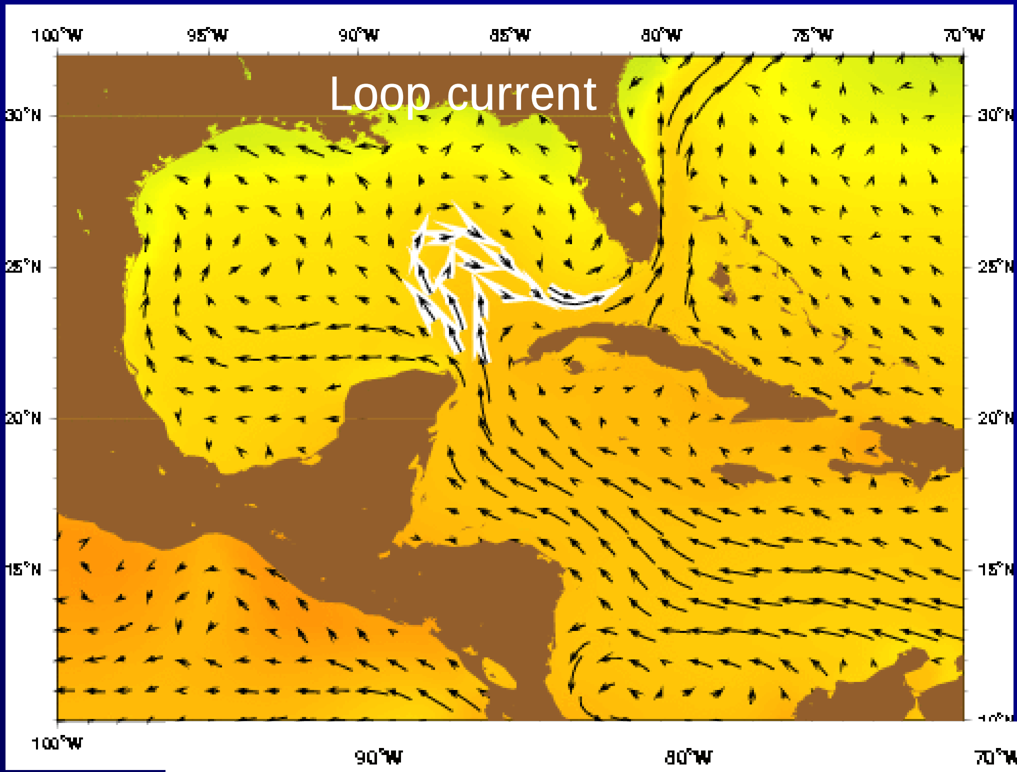
Stock Identification

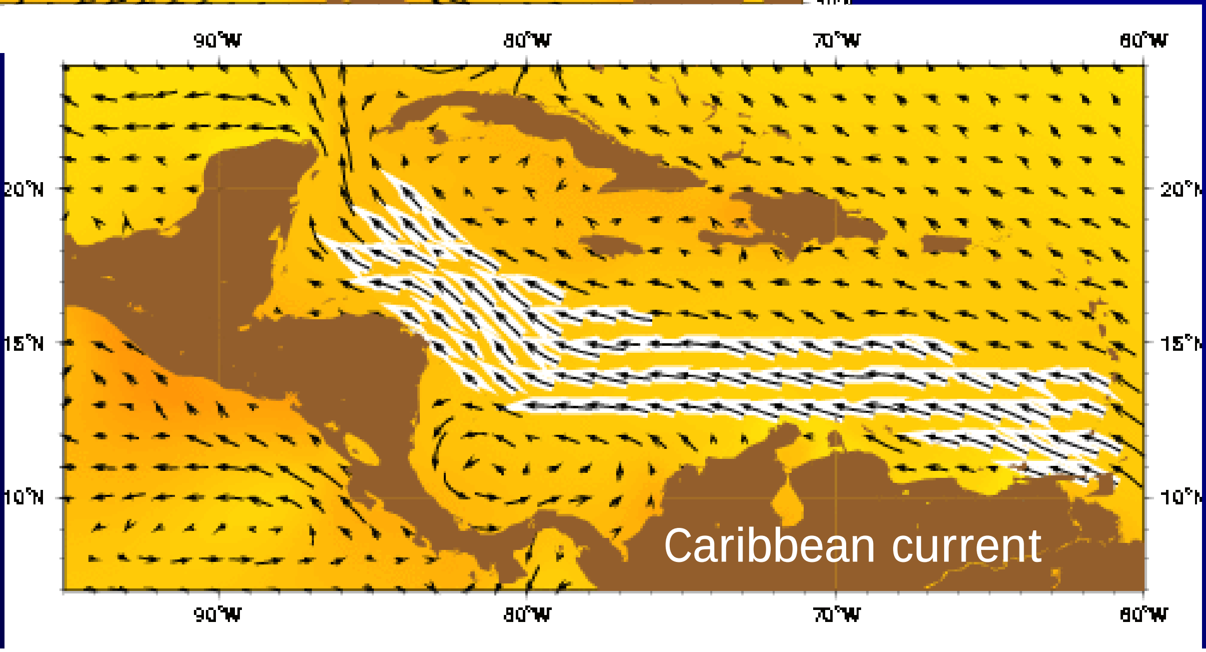


Caribbean Basin

RSMAS, University of Miami

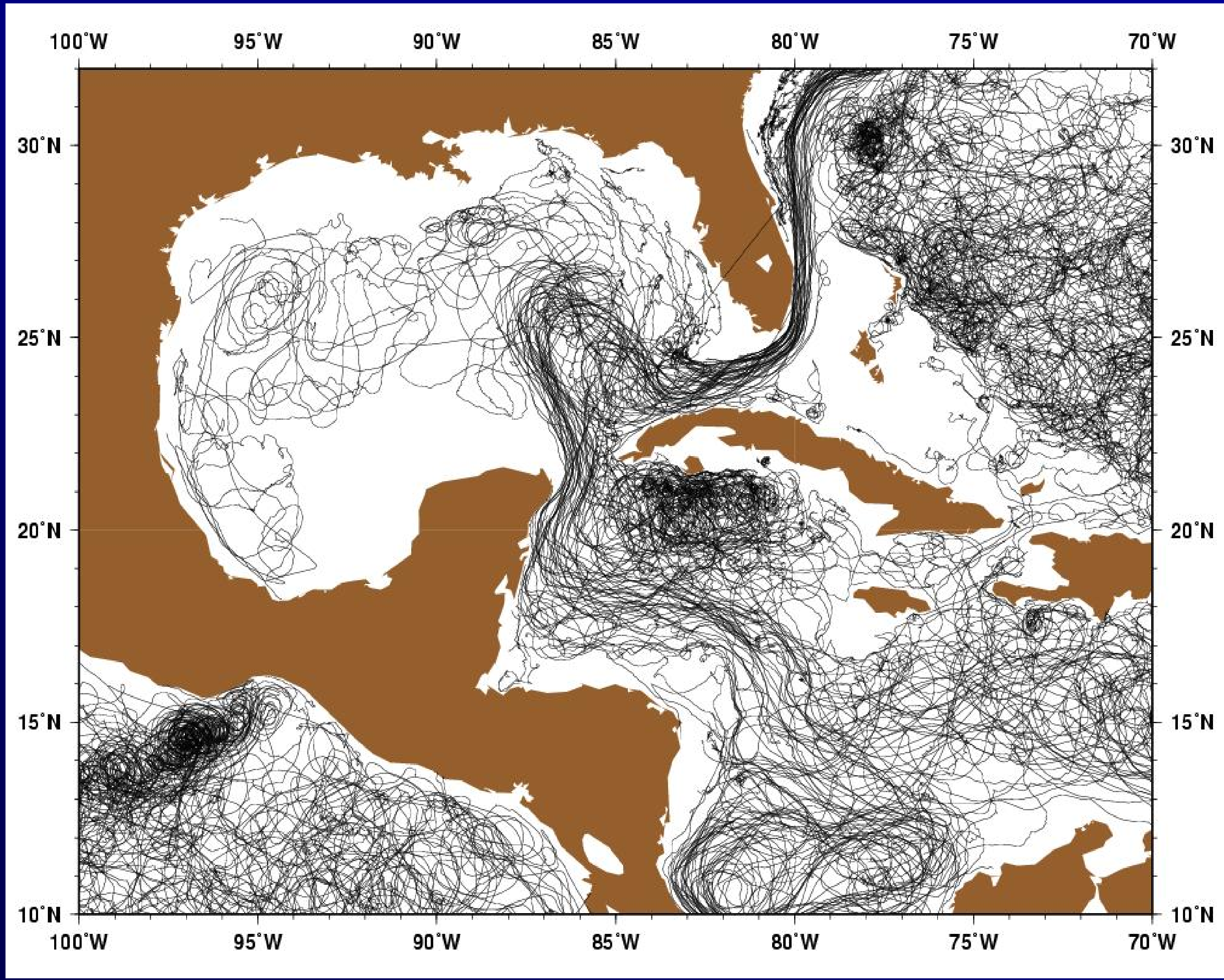
Stock Identification





RSMAS, University of Miami

Stock Identification



Drifter tracks showing the Caribbean, Loop, and Florida currents

RSMAS, University of Miami

Silberman et al. 1994 concluded from mtDNA analyses of 259 spiny lobsters which found 187 haplotypes (168 haplotypes were unique to single lobsters) that spiny lobster are a single stock shared by many countries

Habitat



Growth

Numbers of recaptures by tagging program			
Program	Years	Recaptures	Complete Data
DNR	1978-1979	3372	3132
DRG	1998	47	32
EL	1967-1969	69	30
FWC Adult Monitoring	2003	330	330
UF	1975-1977	3026	2934
		6844	6458

1085 (17%) of the recaptures grew

Lobster grow by molting (discontinuous) and can be thought of as two processes: intermolt period and change in size

Intermolt period

$$P = \frac{e^{(1.233-1.458\,Season+0.538\,Sex-0.0643\,CL+0.0696\,Days\_free)}}{(1+e^{(1.233-1.458\,Season+0.538\,Sex-0.0643\,CL+0.0696\,Days\_free)})}$$

Change in size

$$\Delta CL = e^{(2.009-0.263\,Season+0.133\,Sex-0.00644\,CL+0.00407\,Days\_free+0.0674)}$$

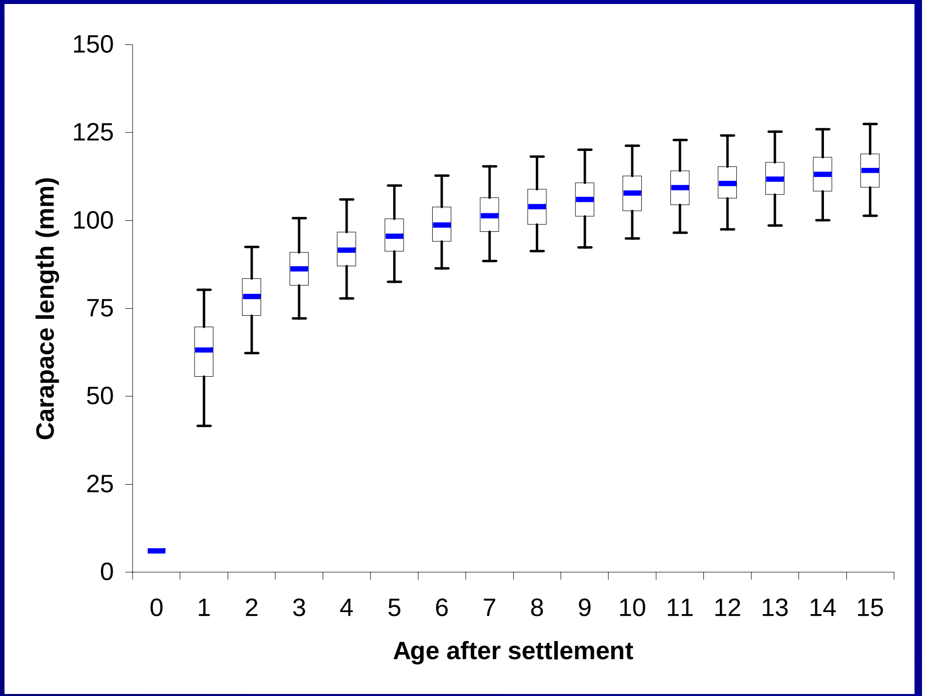
Neither area (Upper vs Lower keys) nor bay (Atlantic vs Gulf) were significant.

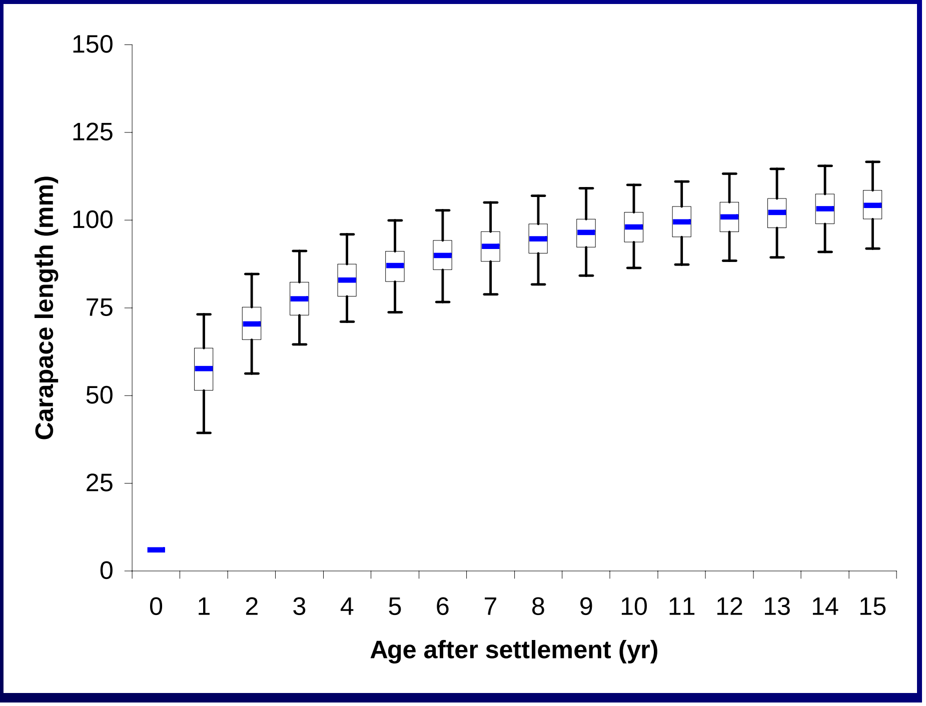
Growth

Males

Tagging

Females



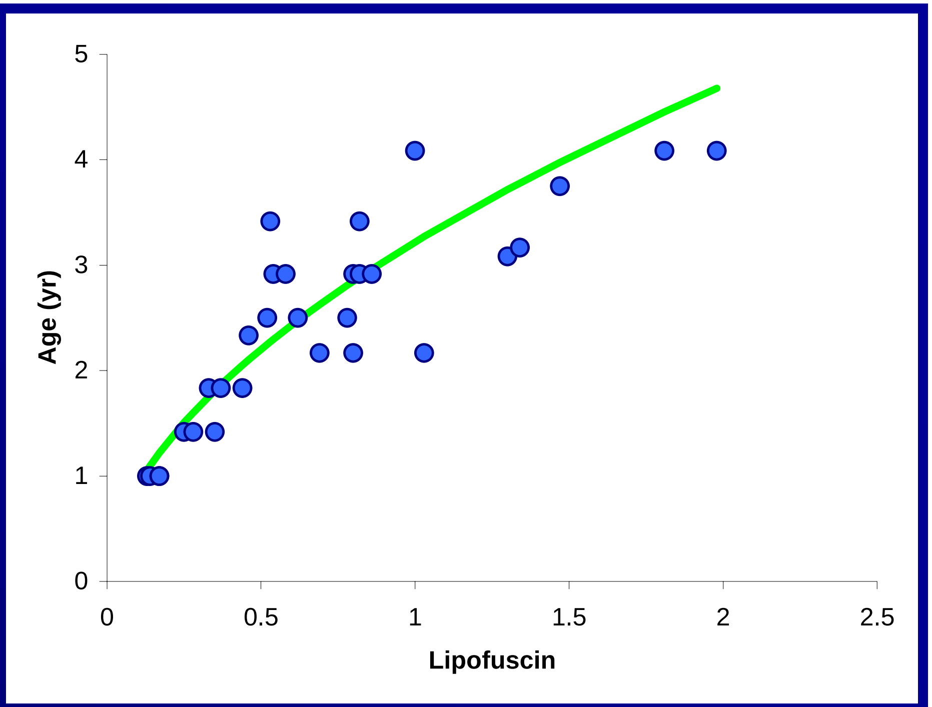


Monthly trajectories of growth for 1000 lobsters of each sex over 15 years based on combined tag-recapture data from 1960-2003

Growth

Males

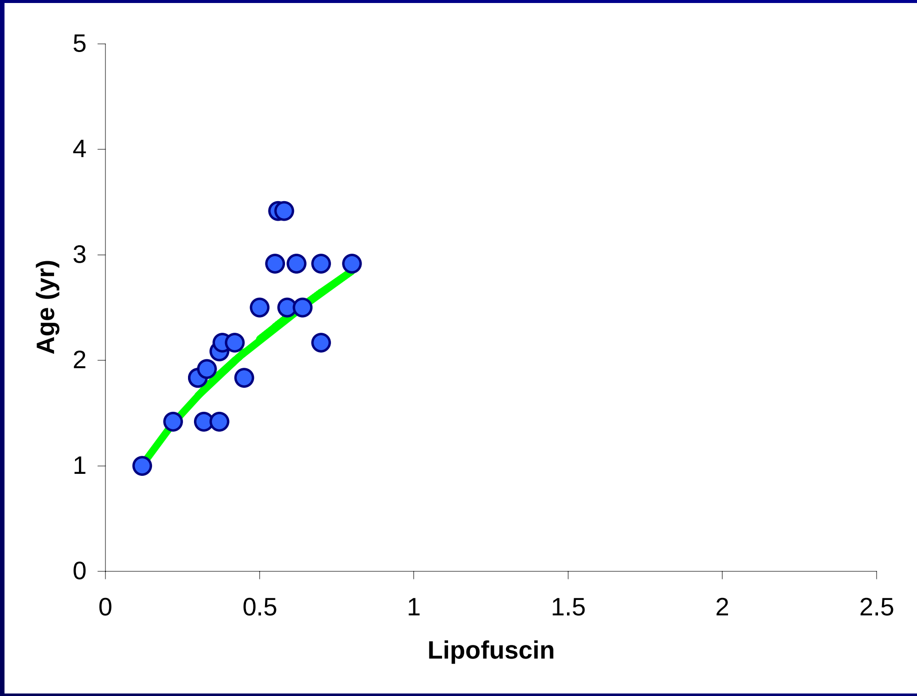
n = 30



Lipofuscin and age in laboratory raised lobsters

Females

n = 21



$Age = 38.6\ Lipo^{0.548}$

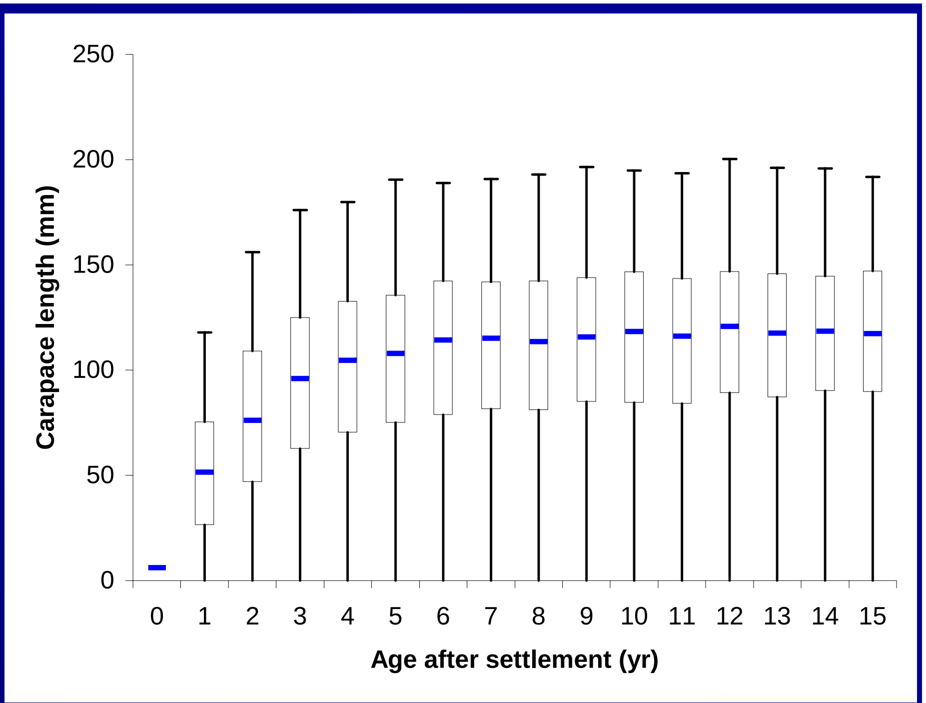
$R^2 = 0.799$, df = 49

Growth

Males

Linf = 128.2 (36.6)

K = 0.60 (0.444)

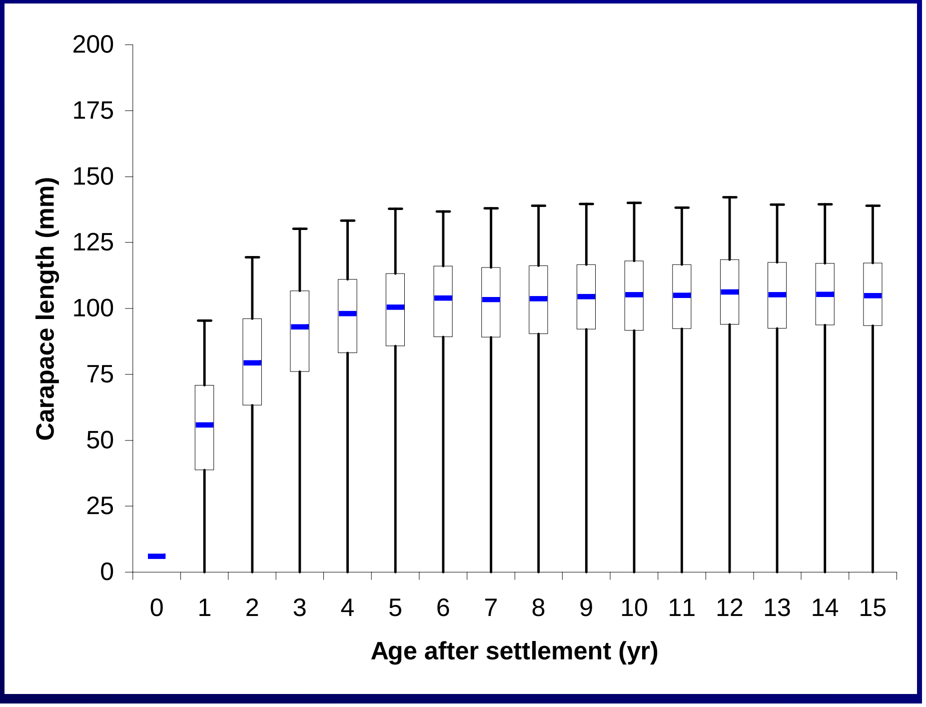


Lipofuscin – Florida Keys

Females

Linf = 107.9 (16.9)

K = 0.78 (0.428)

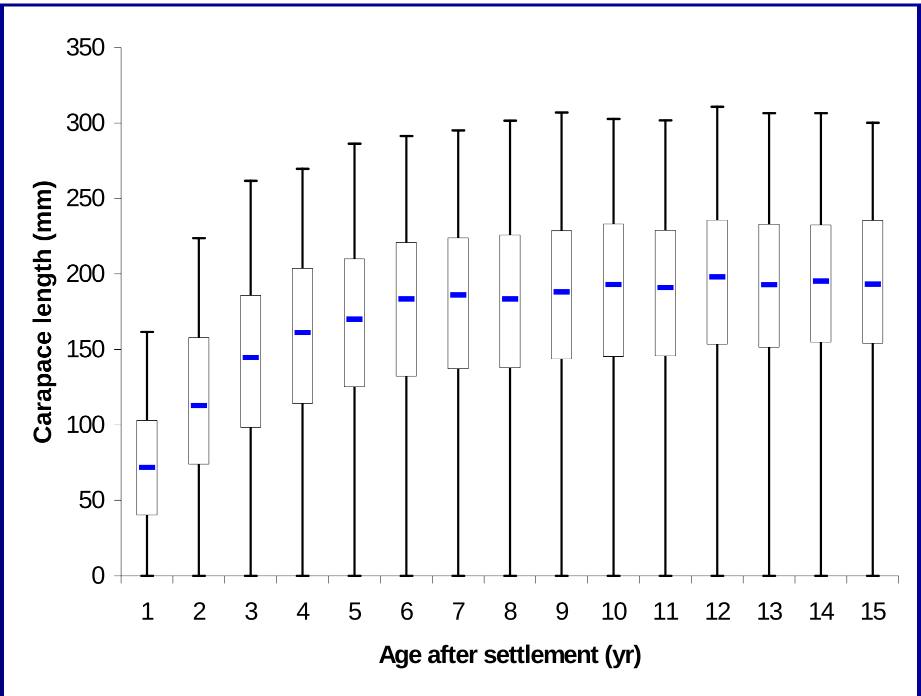


Growth

Males

Linf = 209.1 (52.9)

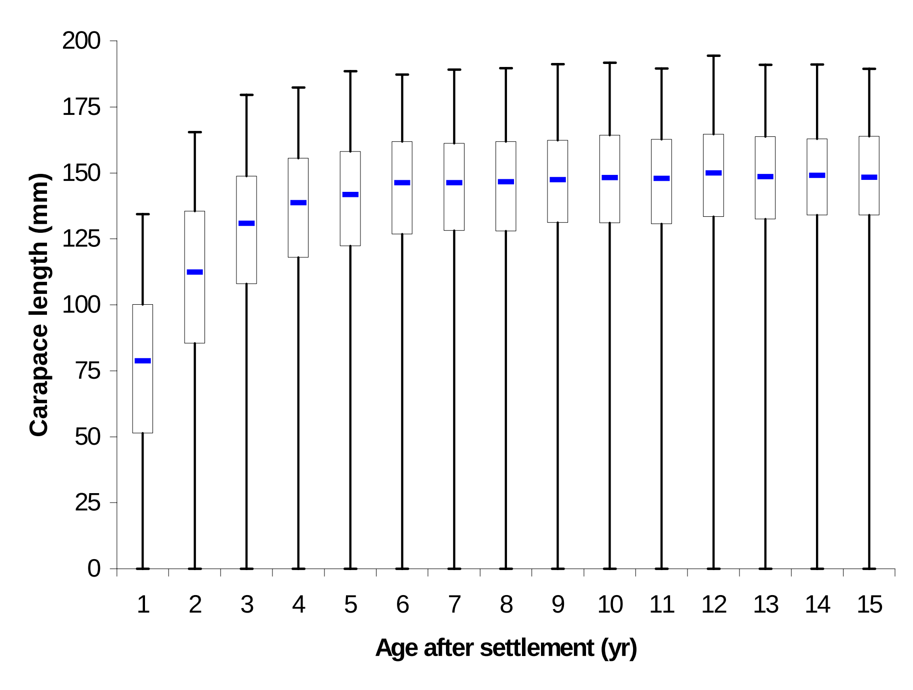
K = 0.47 (0.316)



Lipofuscin – Dry Tortugas

Linf = 152.6 (20.7)

K = 0.74 (0.464)



Growth

Base models used growth from tagging and the lipofuscin based growth estimates were used in sensitivity runs.

Reproduction

- Spawning offshore on reef tract
- 50% maturity at 67 mm CL for females and 98 mm for males in the Florida Keys
- Larger females may have two broods per season because they mate and spawn earlier in the spawning season (April-August)
- Eggs per brood = 91.9 CL^2 – 231212 Bertelsen and Matthews (2001)

Reproduction

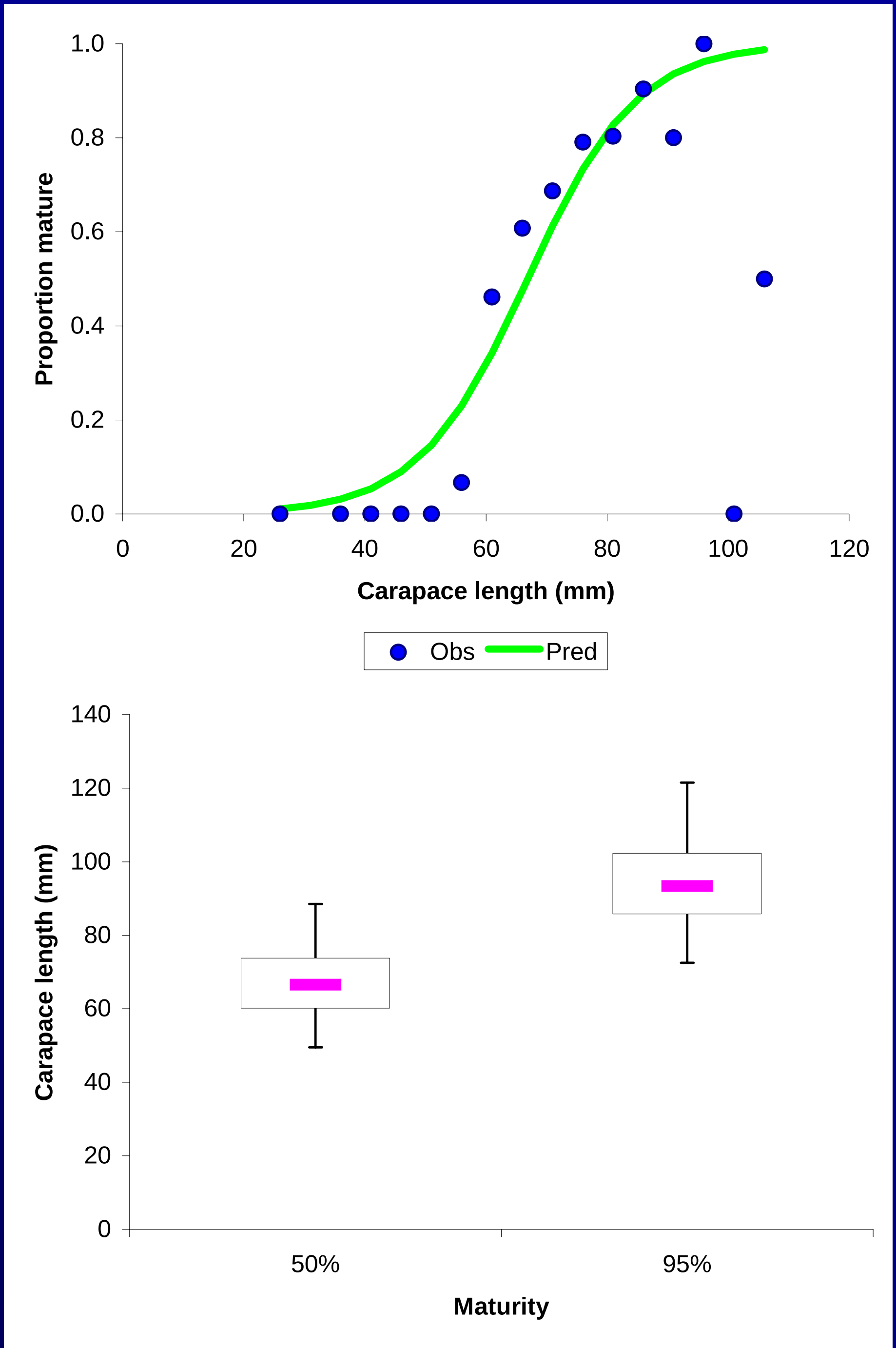
April-July only

n = 845

$$m = \frac{\exp(0.111CL - 7.43)}{(1 + \exp(0.111CL - 7.43))}$$

Medians
50% = 67 mm
95% = 93 mm

Female maturity as a function of carapace length



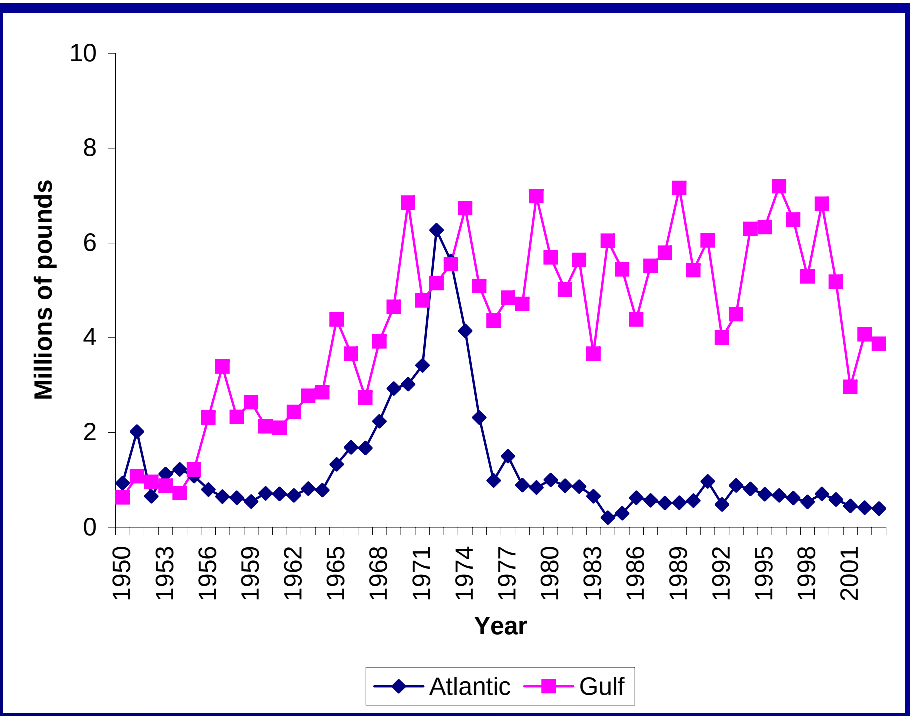
Regulations

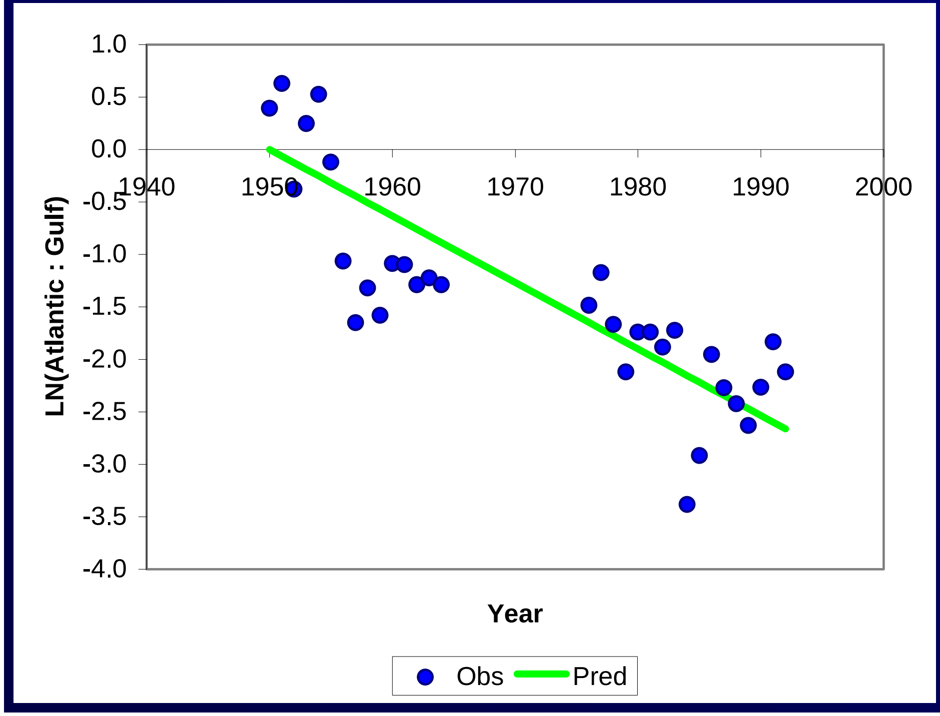
- Prohibition on taking females with eggs
- Minimum size 3 inches (76.2 mm) 1965
- Open season August 6 – March 31 1988
- Two-day recreational sport season in last full weekend in July 1988
- Live wells for holding undersized lobsters 1987
- Recreational bag limit 6 per person/ 24 boat 1987
- Daily 50 lobster bag limit for holders of Special Recreational Crawfish license 1994
- 250 lobster per day per diver for commercial divers 2003
- Prohibits the harvest of lobsters from artificial habitat 2003

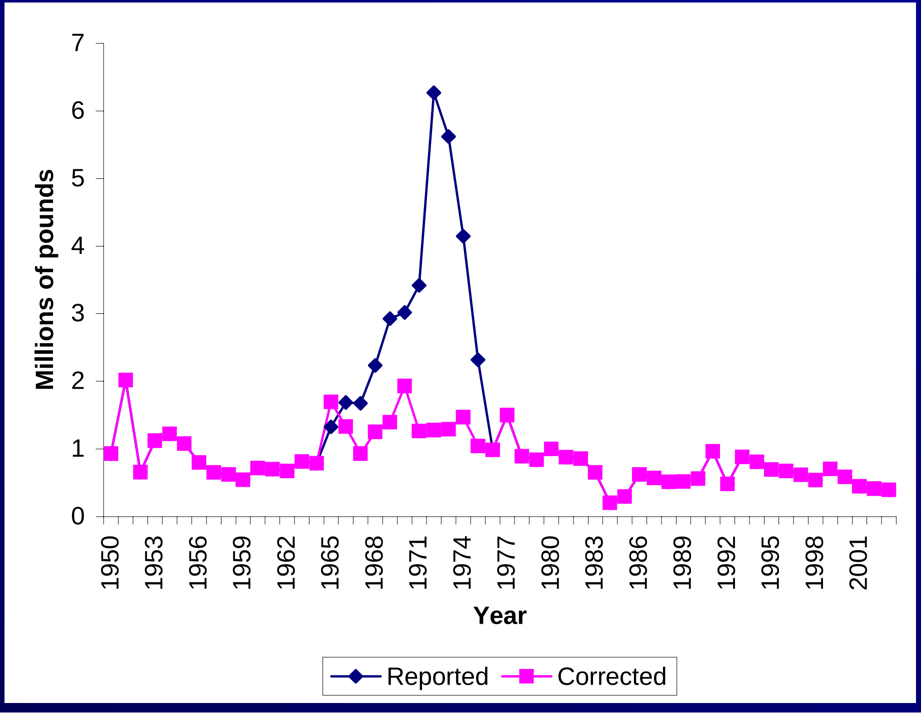
- Landings
  - Commercial
    - Adjusting for Bahamian harvests
    - Western Atlantic commercial landings
    - Historical U. S. commercial landings
  - Recreational

Landings

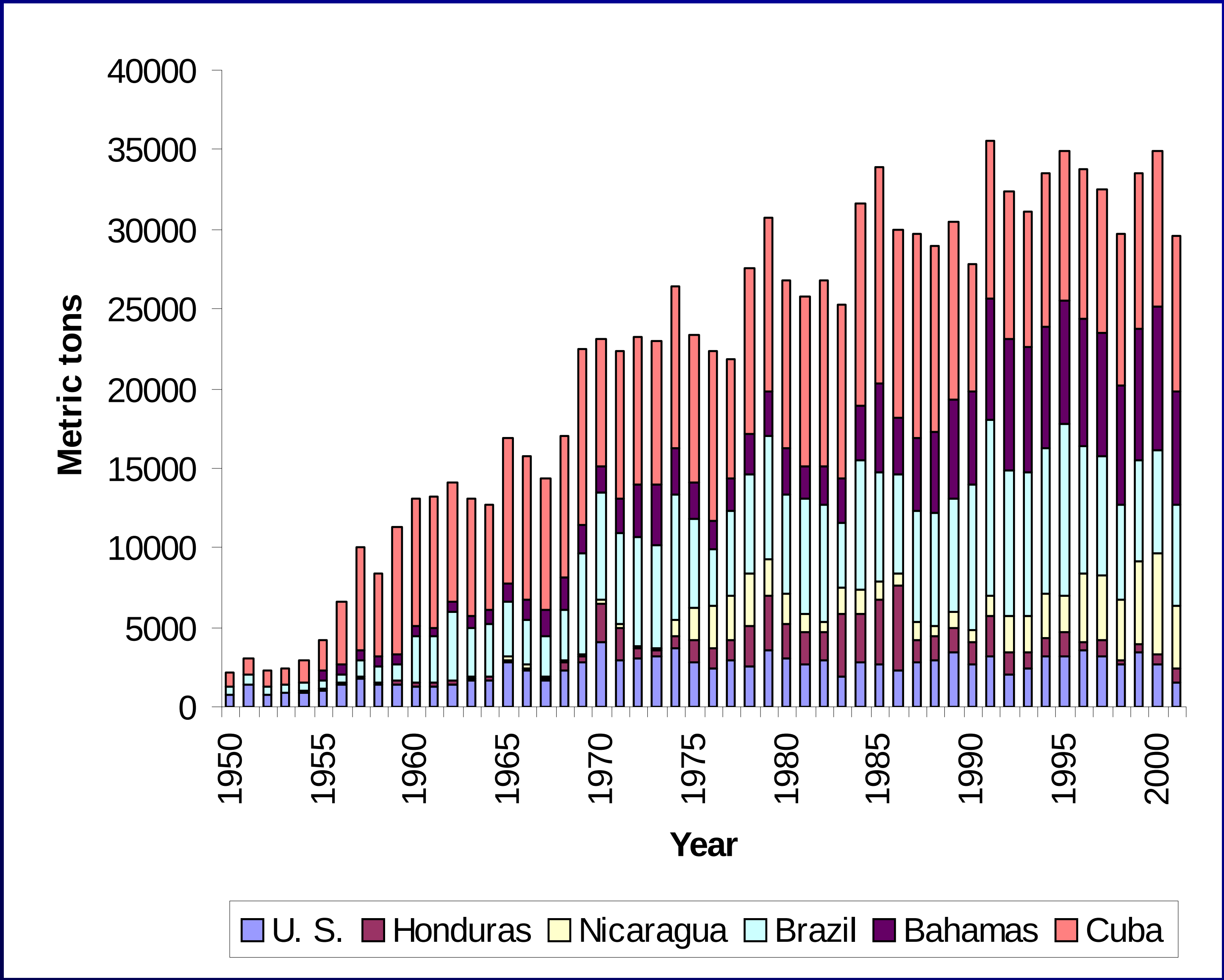
Adjusting the Florida Atlantic coast landings from 1965-1977





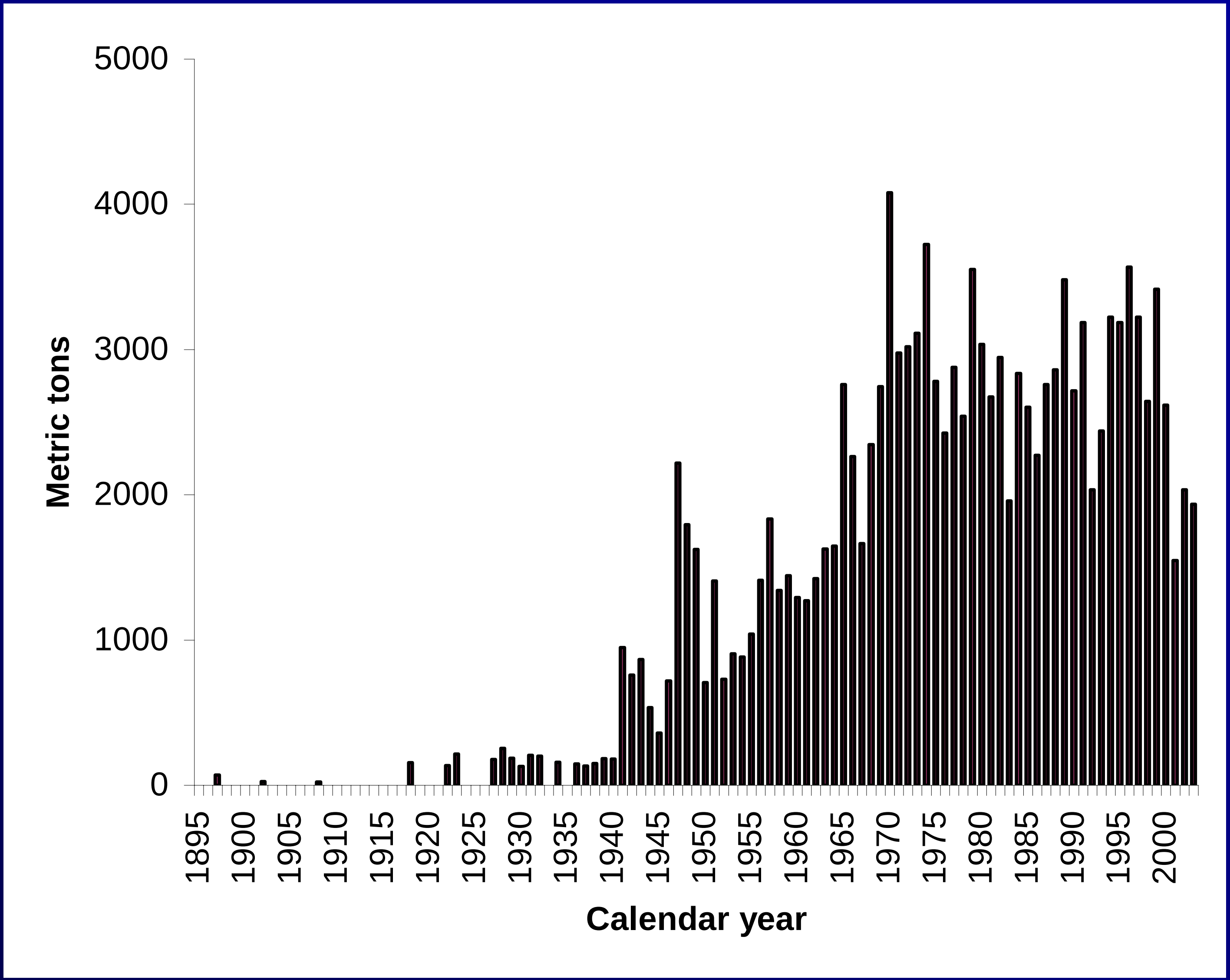


Landings



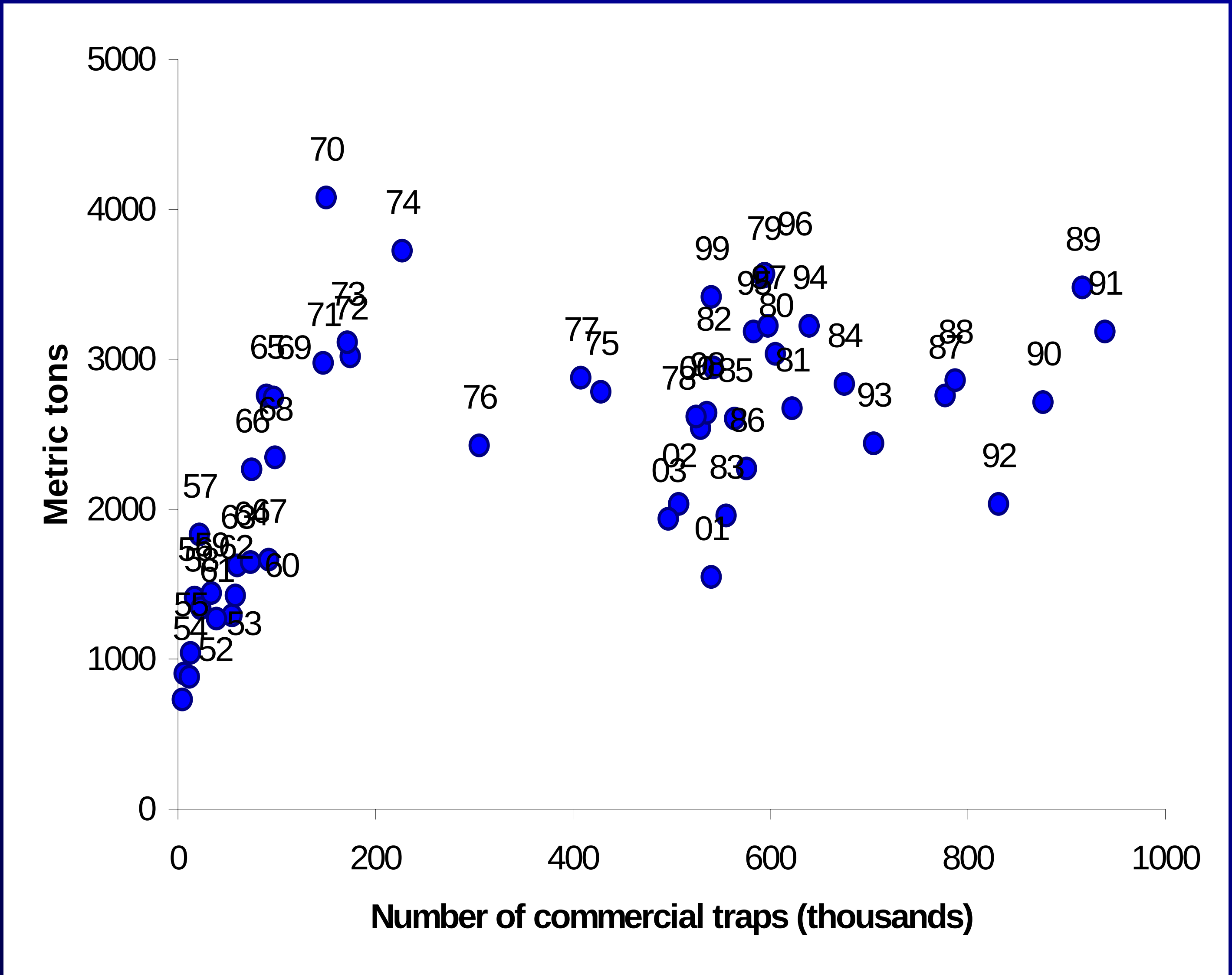
Annual landings by major lobster producing countries in Caribbean (FAO Western Atlantic)

Landings



Historical S.E. United States commercial spiny landings

Landings



Statewide commercial landings and the claimed number of traps

Landings by fishing year

- Commercial 1978-79 +
- Florida trip tickets 1985-86 +
- Recreational from mail survey 1992-93 +
- Special Recreational License 1994-95 +

Recreational landings and estimated bait usage was extended back to 1985-86 using August commercial landings

Landings

Estimating bait usage

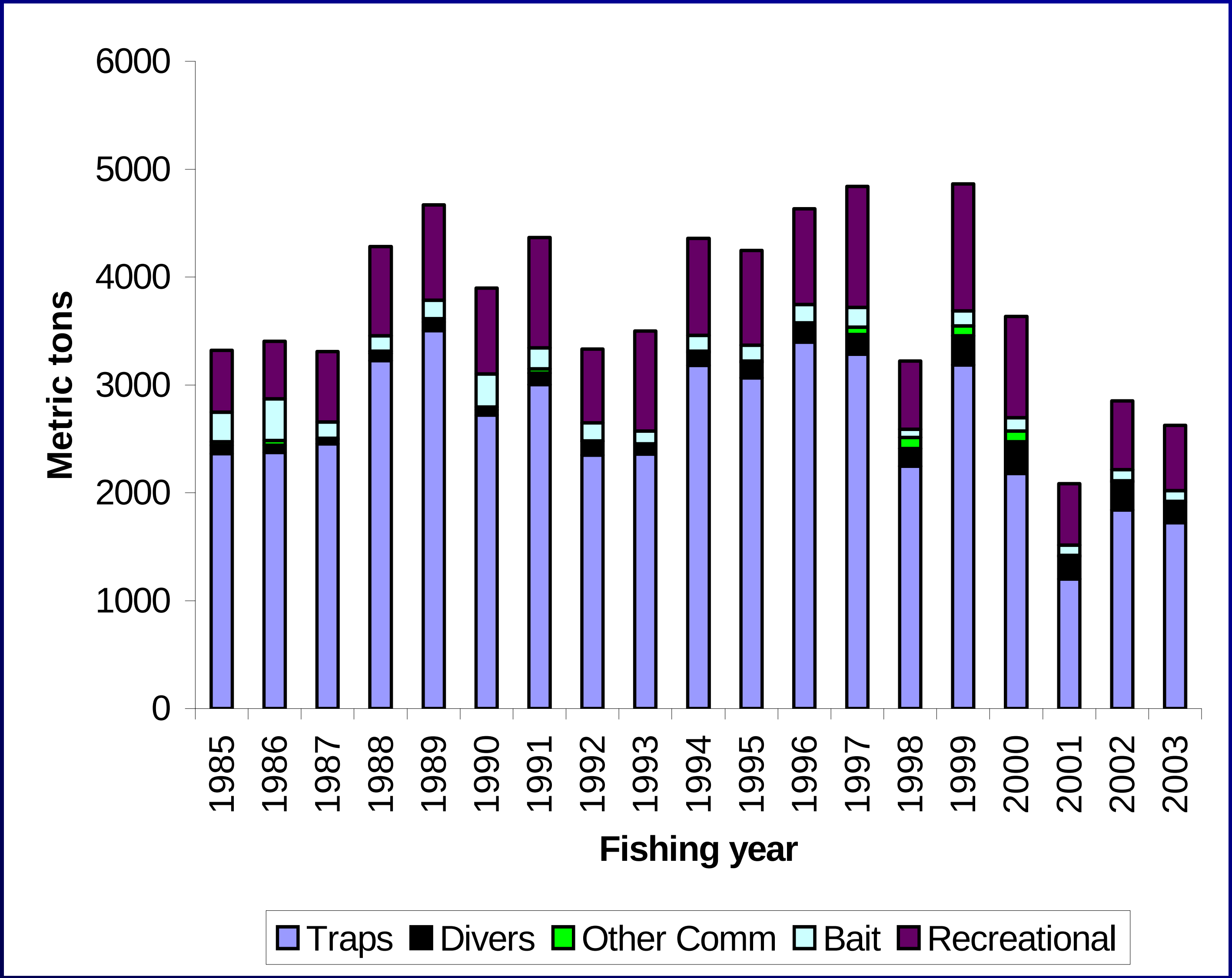
Monthly number of lobsters sub-legal and legal per trap from observer data (1993-2000)

Average number of pounds per trap by month from trip tickets and the monthly trap landings to estimate number of trap hauls

Average soak time by month from trip tickets

Mortality rate in trap 26.3% per 4 weeks prior to 1987 and 10.1% per week afterwards

Landings

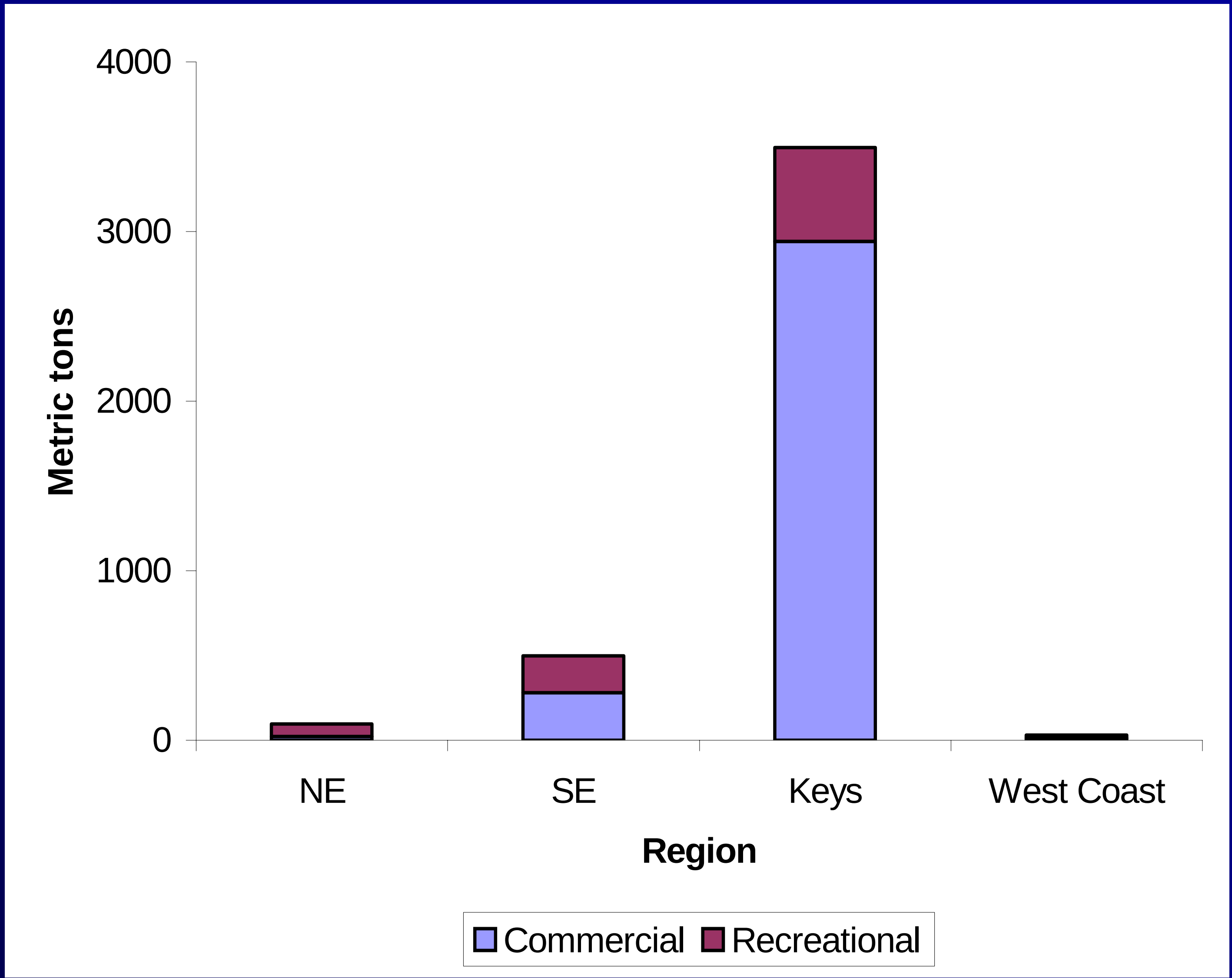


Landings by gear and fishing year

Landings

Spiny lobster regions for matching lengths to landings. The Northeast region extends to North Carolina and the West coast extends to Texas.

Landings



Average 1999-2003 landings by region and sector

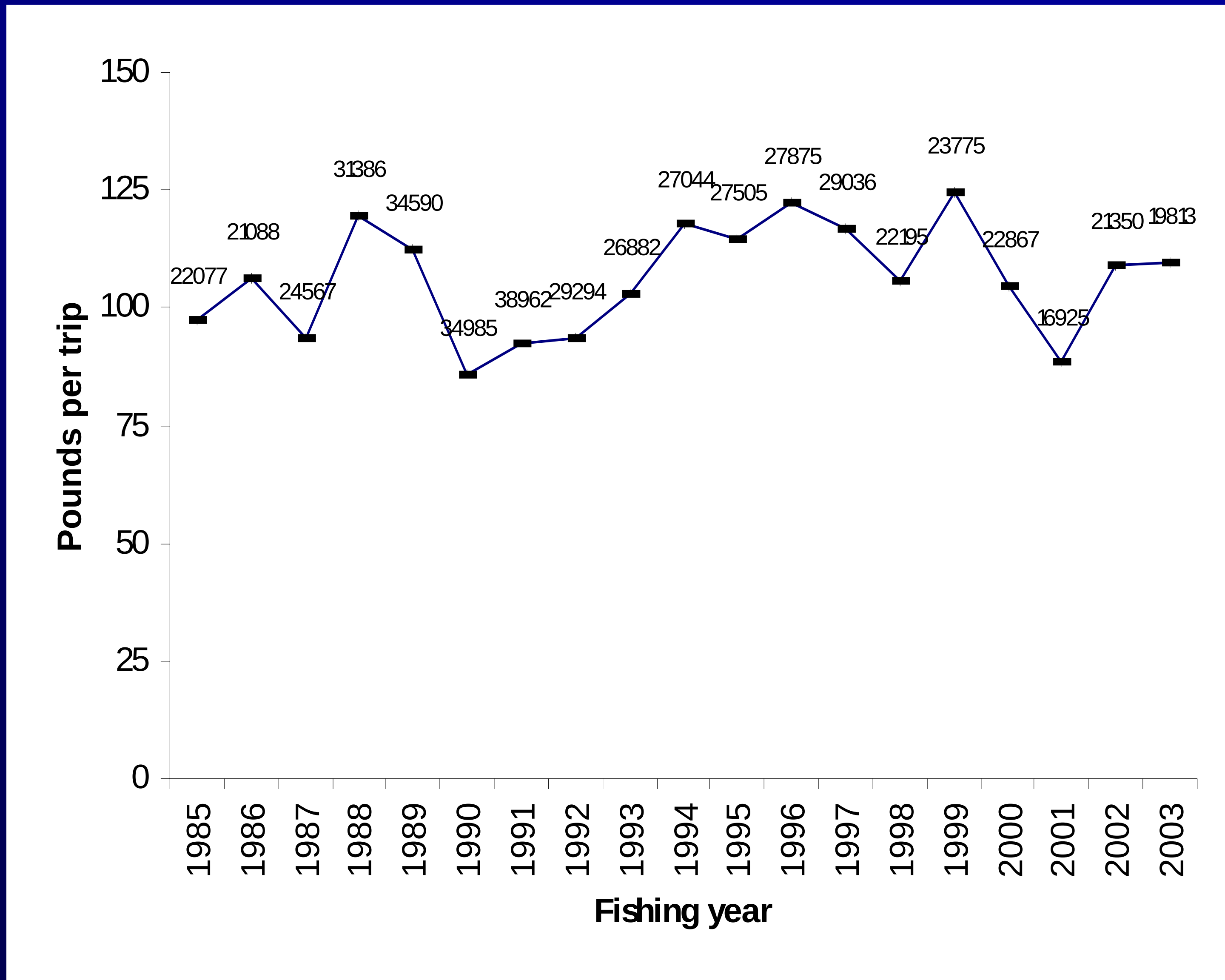
Catch rates

Catch rates were standardized with generalized linear models to account for terms such as gear, month, number of anglers, soak time, number of traps, or region.

If the units were in numbers then a Poisson distribution with a log link was used, if the units were in biomass then a gamma distribution with a power link was used, or for proportions then a binomial distribution with a logit link.

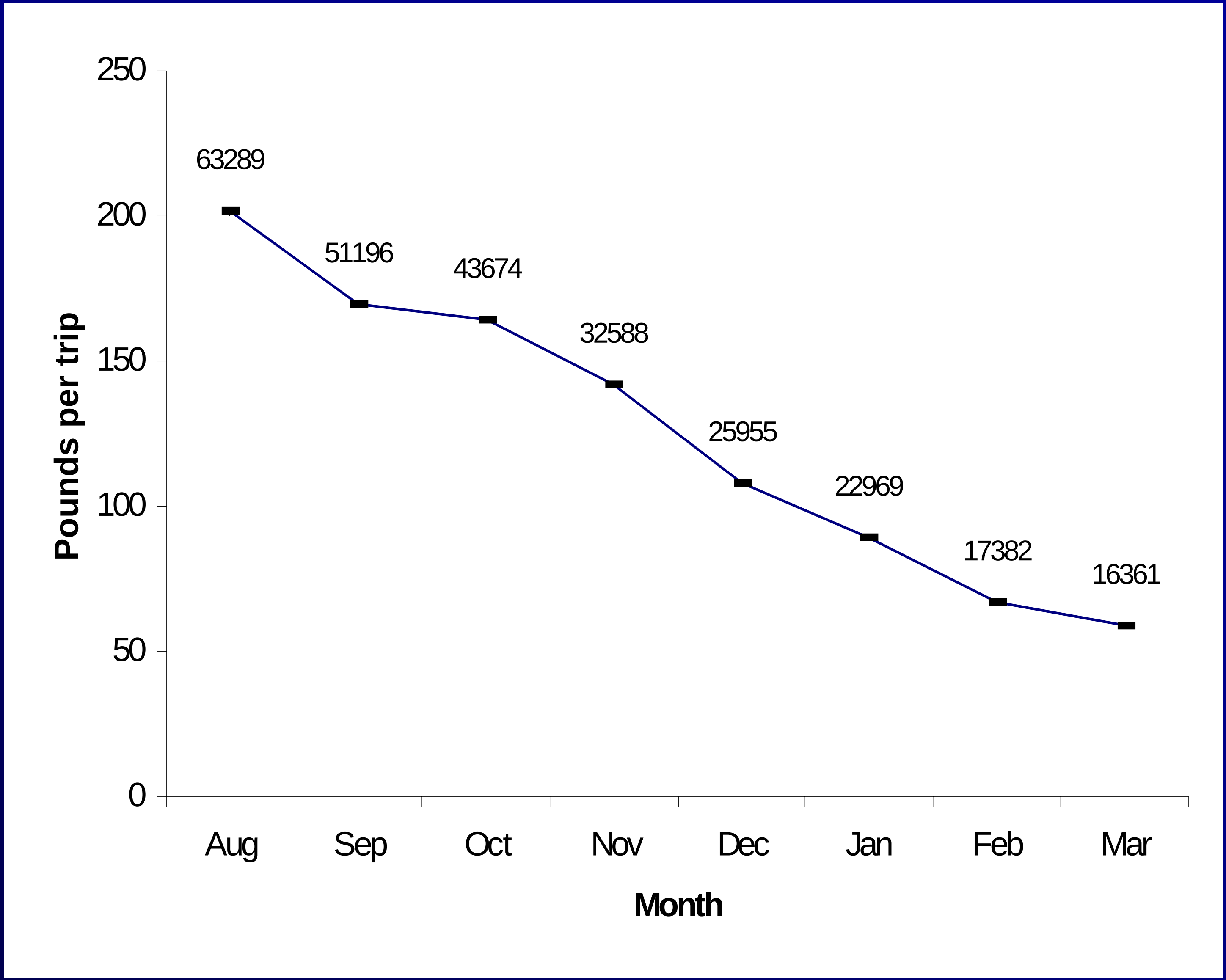
The 95% confidence interval, inter-quartiles, and medians were evaluated through 1000 Monte Carlo iterations using standard errors by fishing year.

Catch rates



Combined gears commercial catch rates by fishing year

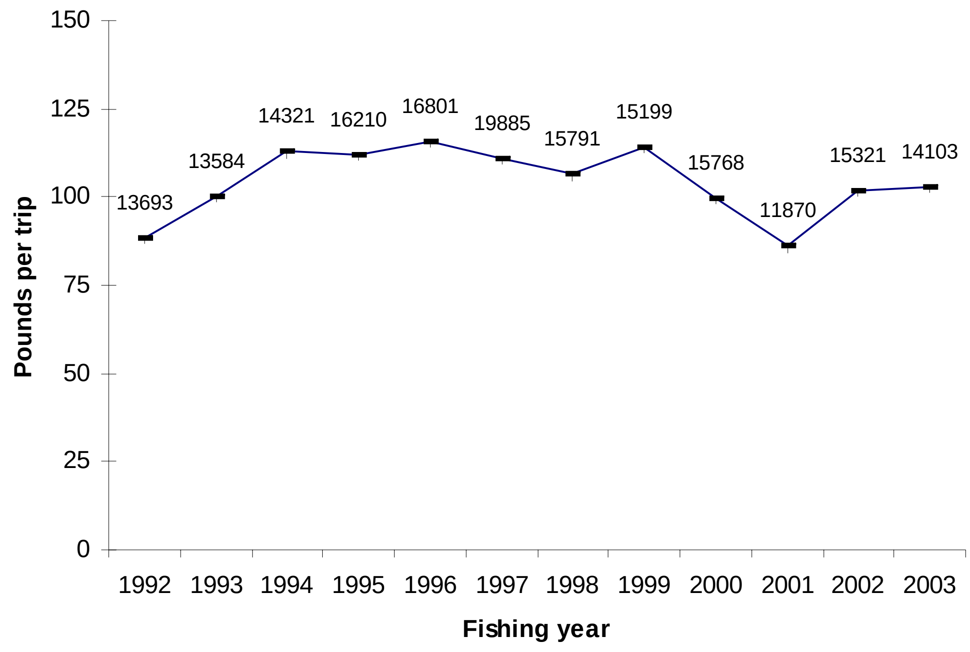
Catch rates



Seasonal commercial catch rates for combined gears

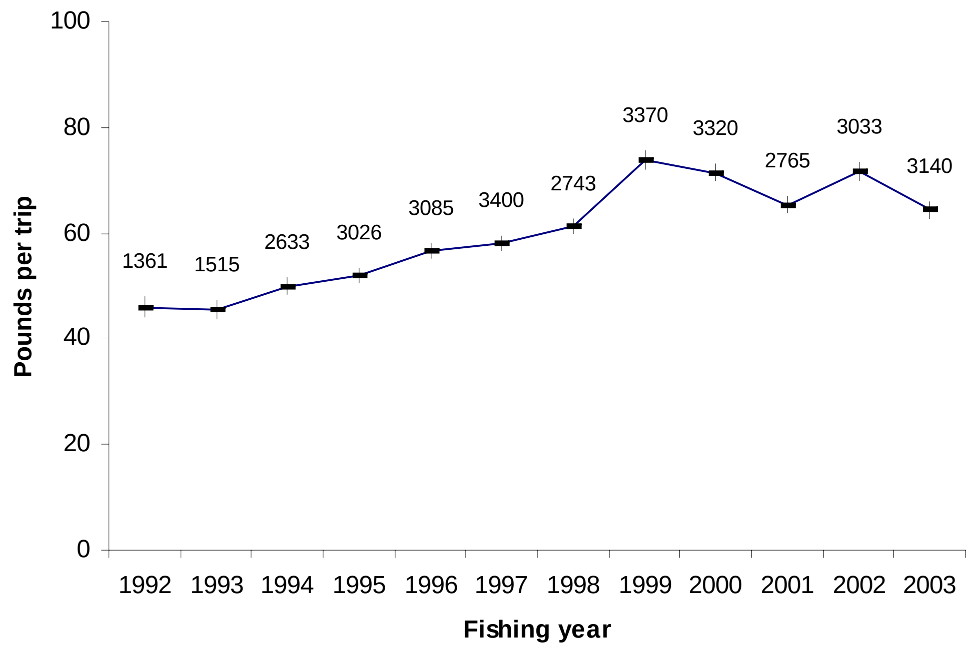
Catch rates

Traps



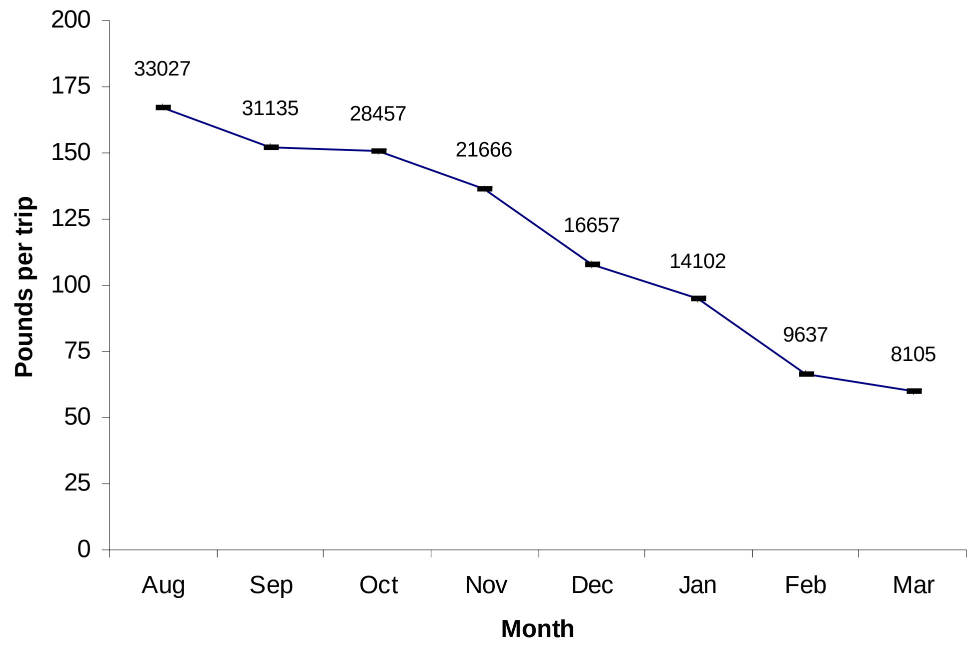
Commercial catch rates by major gear

Divers



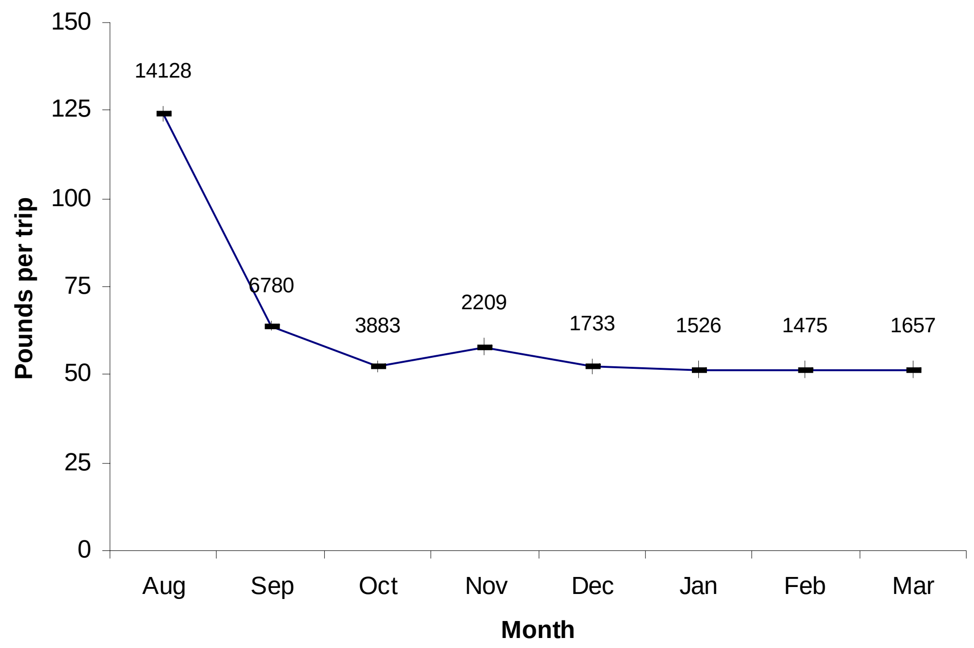
Catch rates

Traps



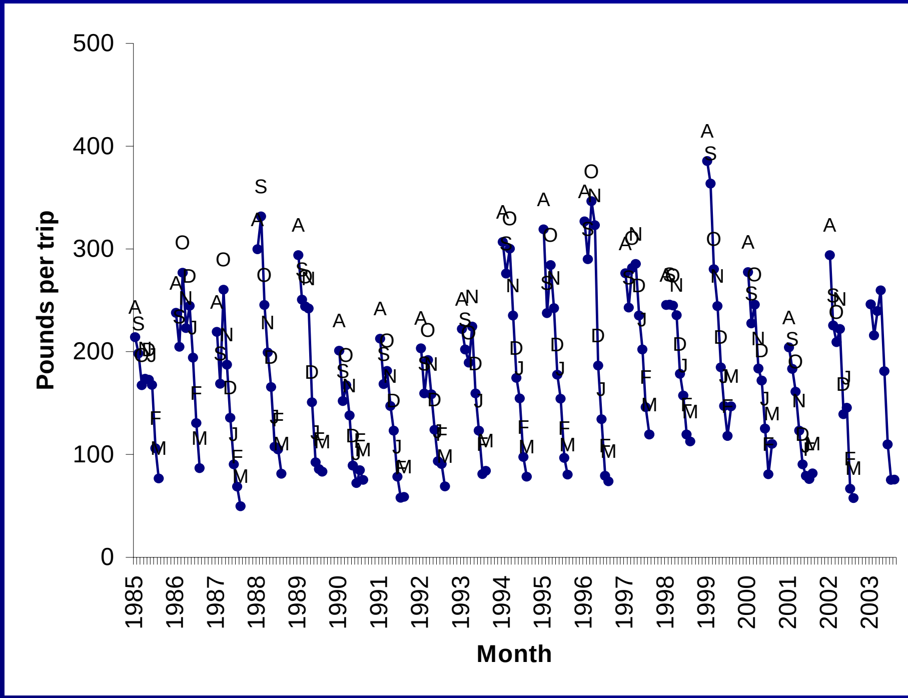
Seasonal catch rates by gear

Divers

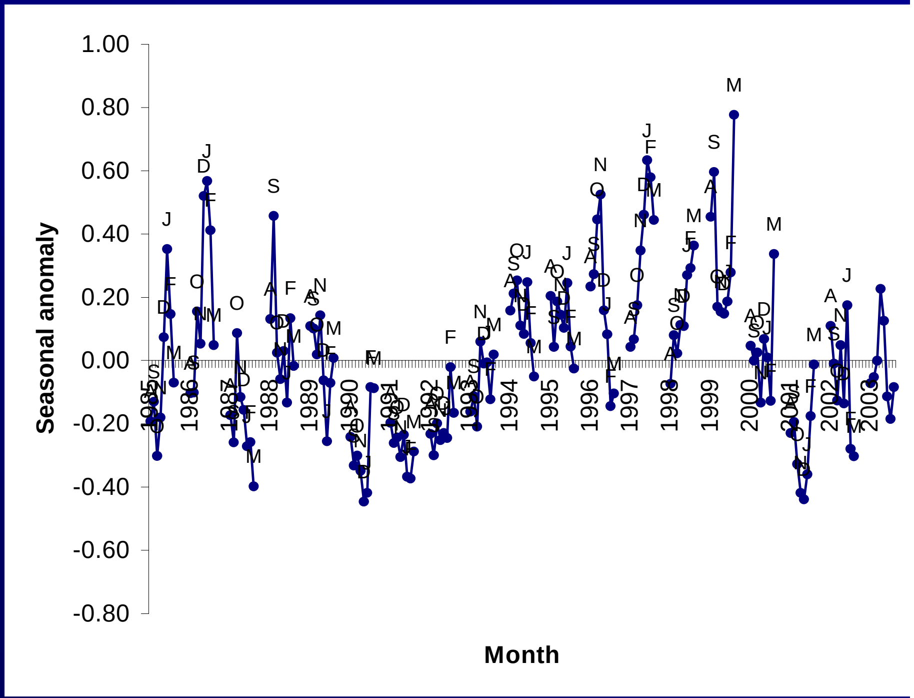


Catch rates

Monthly catch rates by fishing year

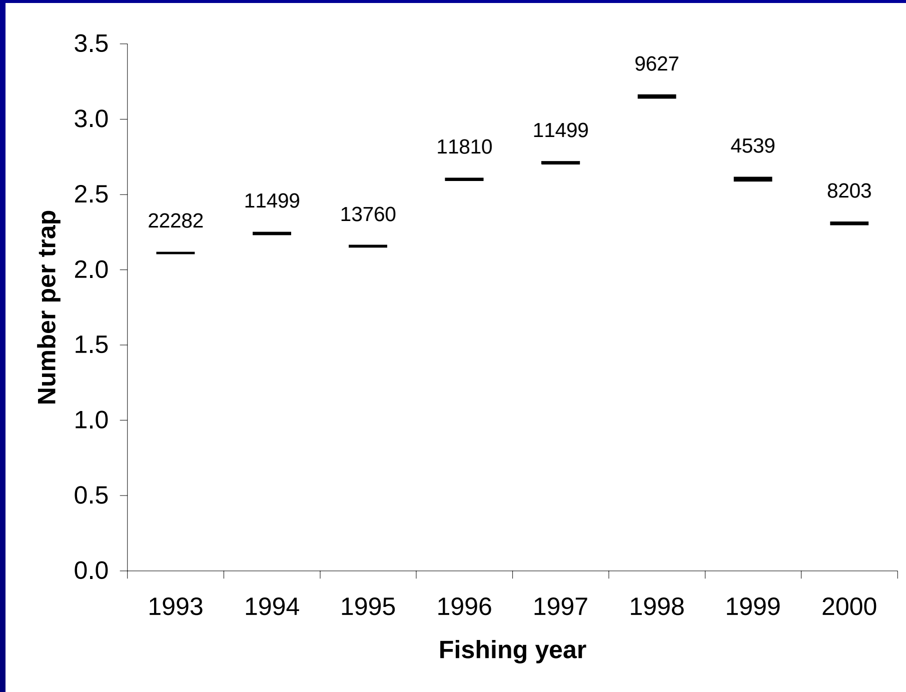


De-trended monthly catch rates

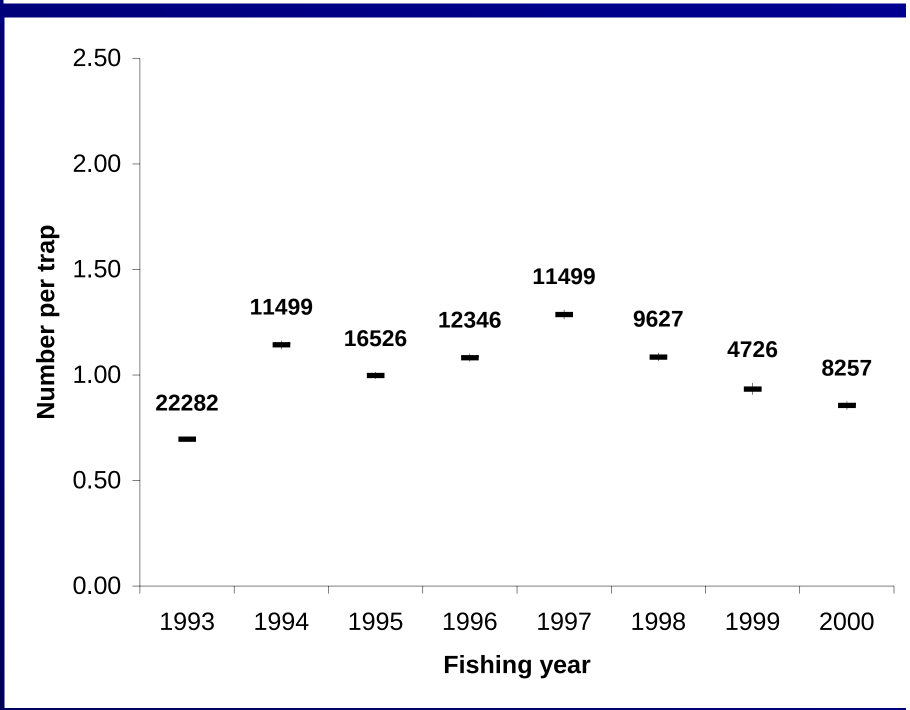


Catch rates

Observer pre-recruits
(47-75 mm CL)

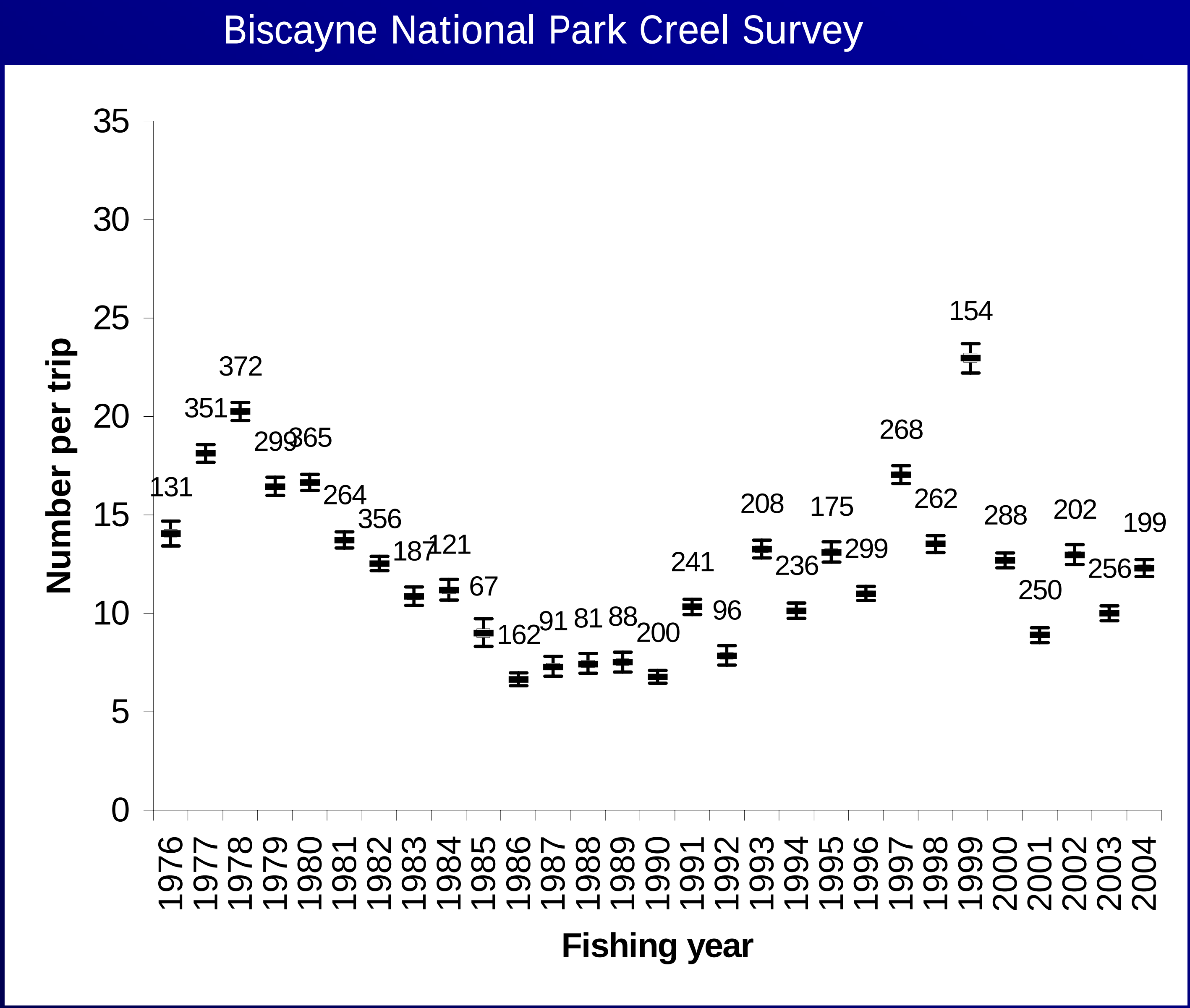


Observer legal-sized
(> 76 mm CL)



Fishery Dependent

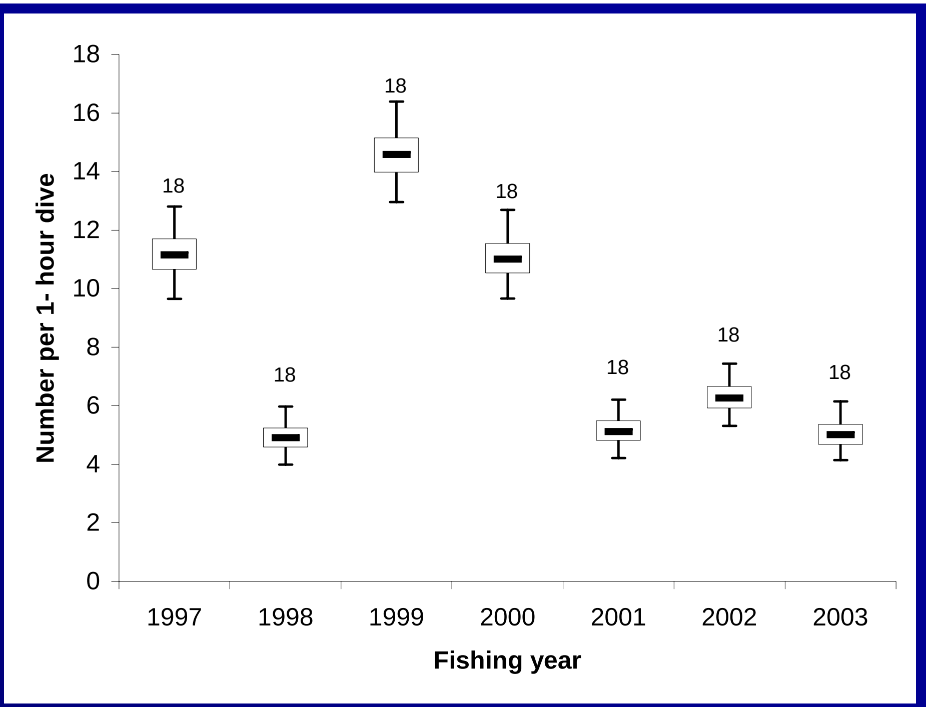
Catch rates



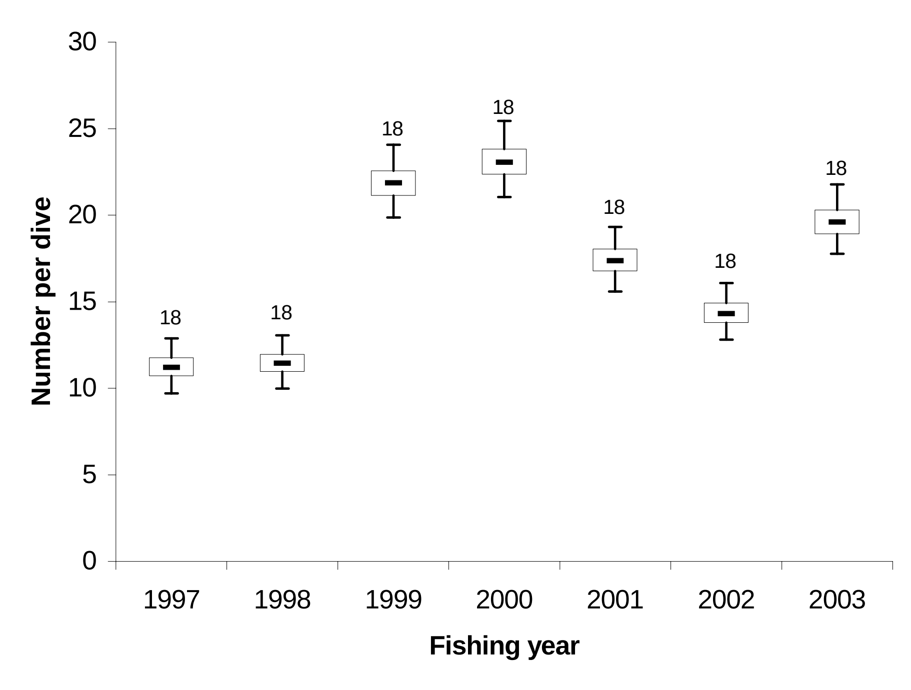
Fishery Dependent

Catch rates

Adult monitoring pre-recruits (47-75 mm CL)



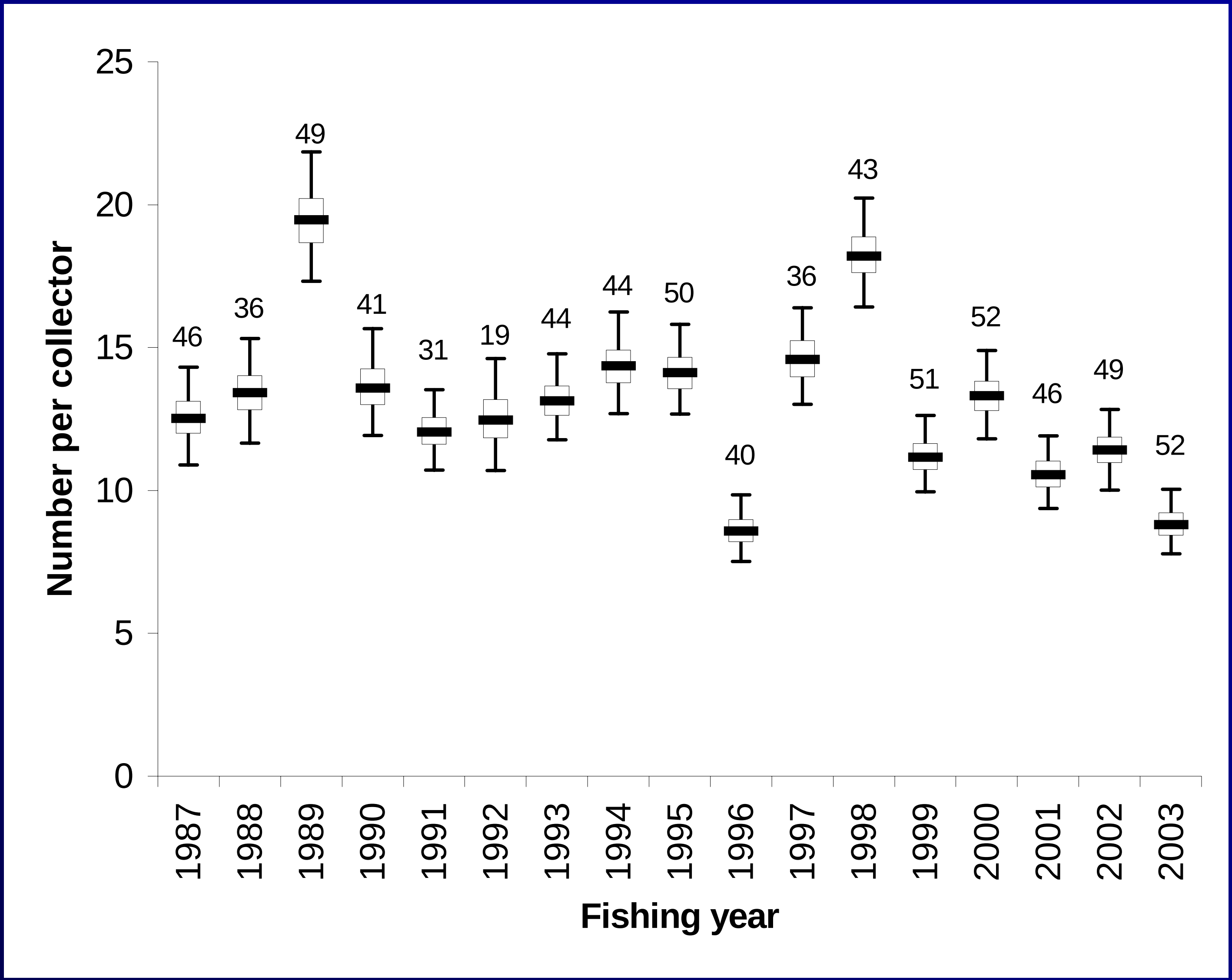
Adult monitoring legal-sized (>76 mm CL)



Fishery Independent

Catch rates

Puerulus Settlement



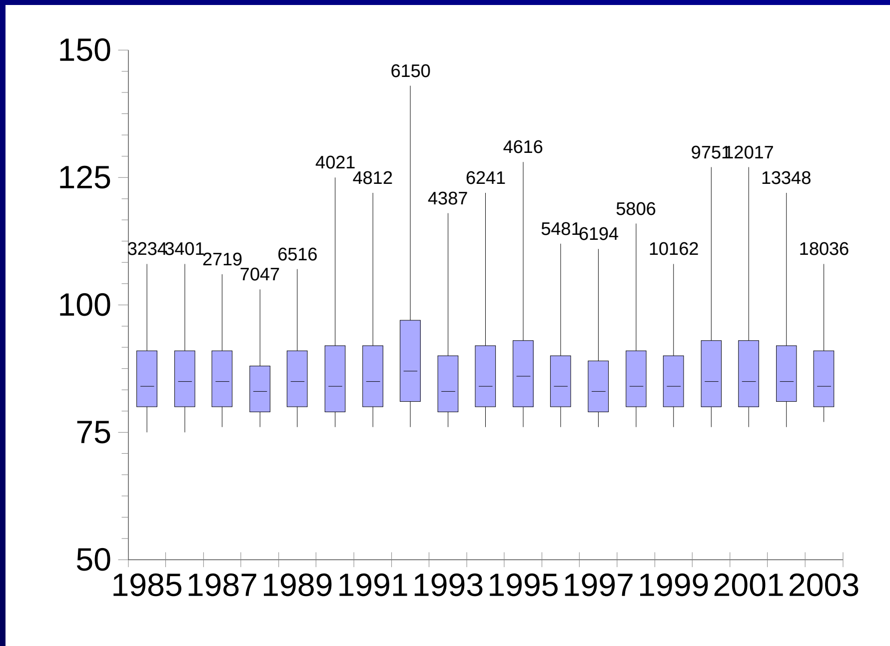
Fishery Independent

Length measurements

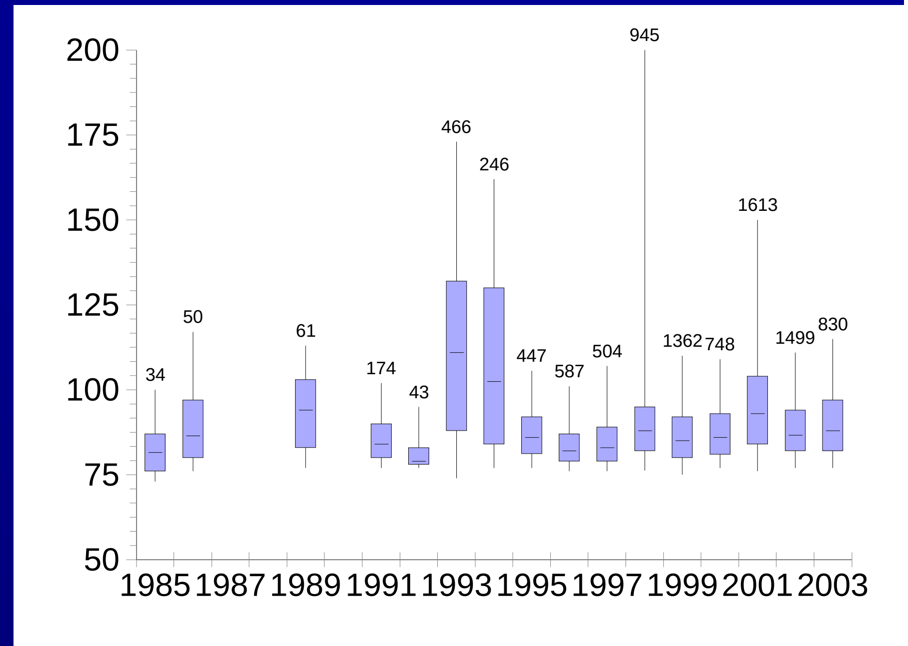
FY	Traps	Divers	Other	Recreational
1985	3234	34	.	.
1986	3401	50	.	.
1987	2719	.	.	830
1988	7047	.	.	810
1989	6516	61	1	883
1990	4021	.	.	1737
1991	4812	174	97	2927
1992	6150	43	1	971
1993	4387	466	2	3297
1994	6241	246	104	2841
1995	4616	447	.	2635
1996	5481	587	.	3712
1997	6194	504	.	2269
1998	5806	945	47	1927
1999	10162	1362	137	2365
2000	9751	748	90	1968
2001	12020	1613	126	2359
2002	13348	1499	92	6493
2003	18036	830	62	2908

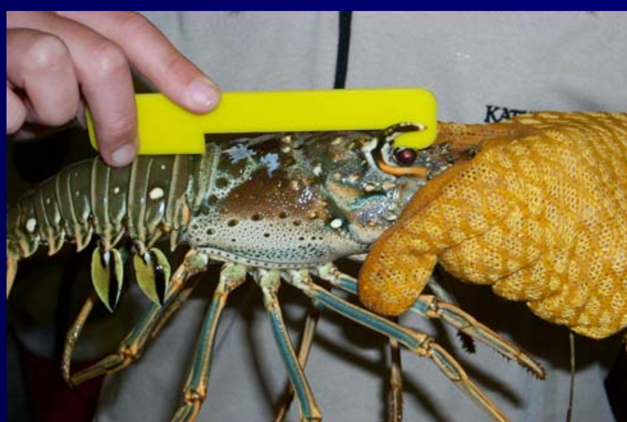
Numbers of lobsters measured by fishing year and gear

Traps

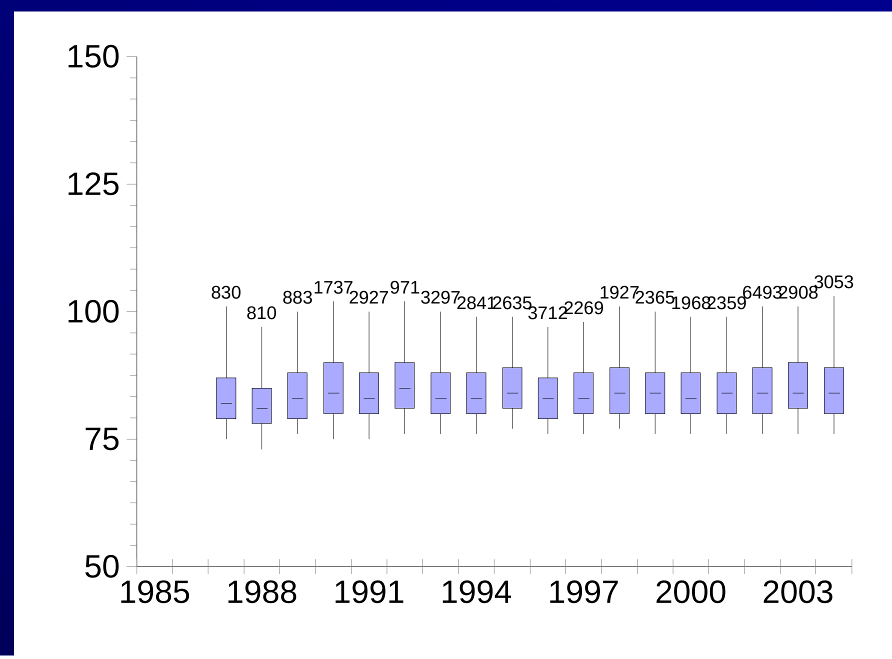


Divers



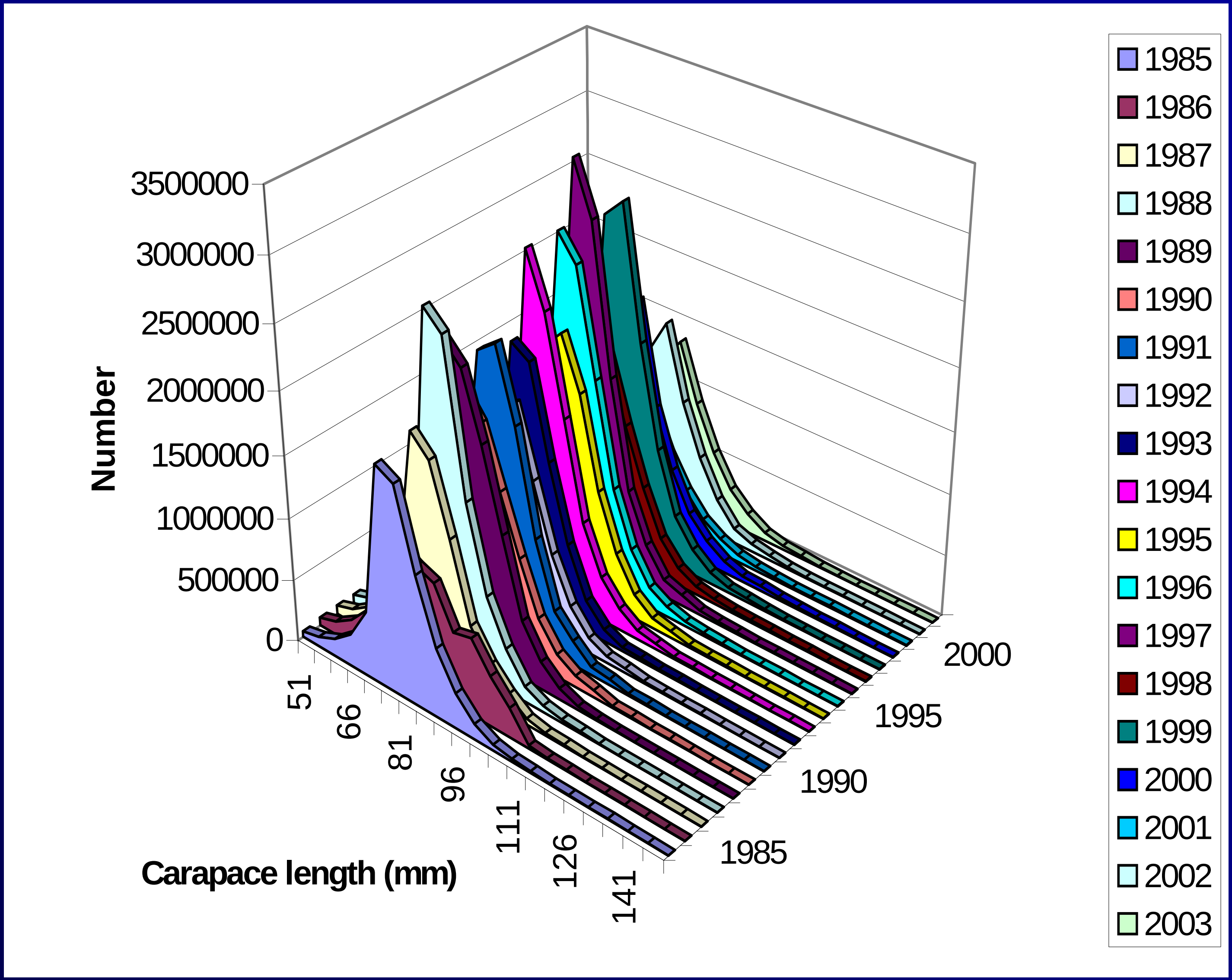


Recreational



Commercial and recreational length measurements by fishing year

Length measurements



Number of lobsters for combined gears by carapace length and fishing year

Assessment models

- Non-equilibrium surplus production
- Modified DeLury
- Integrated Catch-at-Age

Assessment models – Non equilibrium surplus production

ASPIC 5.05

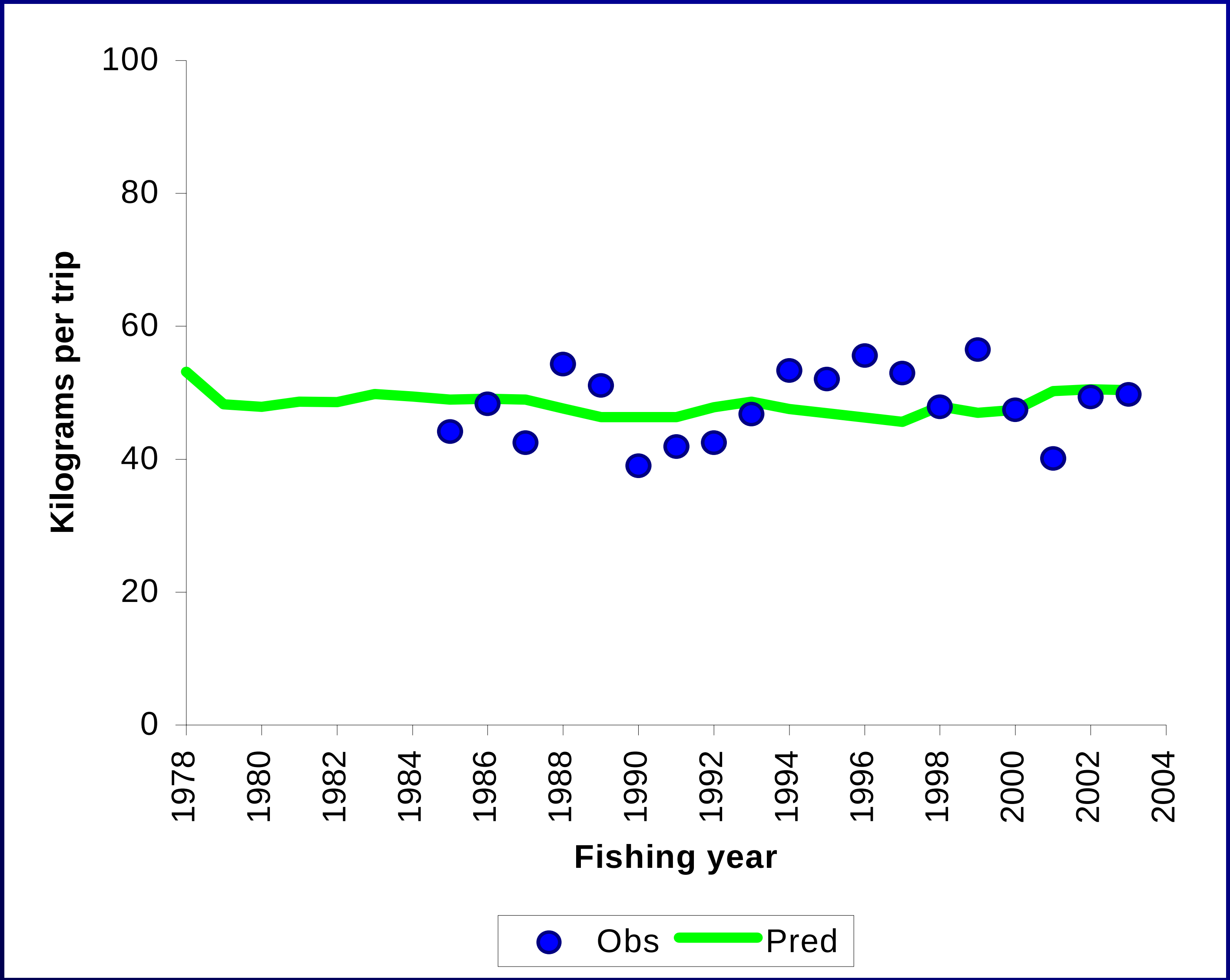
Inputs:

- Landings – by sector and combined (1978-2003) in biomass
- Commercial (kg per trip, 1985-2003)
- Biscayne National Park Creel Survey (kg per trip 1978-2003)

Model: Logistic matching yield

Parameters: B1/K, MSY, K, q(comm), q(BNP)

Assessment models – Non equilibrium surplus production



Neither the CPUE nor the BNP index was significant and the results were unstable. We did not consider this model any further.

Assessment models – DeLury

Input: Commercial and bait catch (numbers) and effort

Recreational (numbers) catch and effort

FWC Observer catch rates (legal and pre-recruits)

FWC Adult monitoring catch rates (legal and pre-recruits)

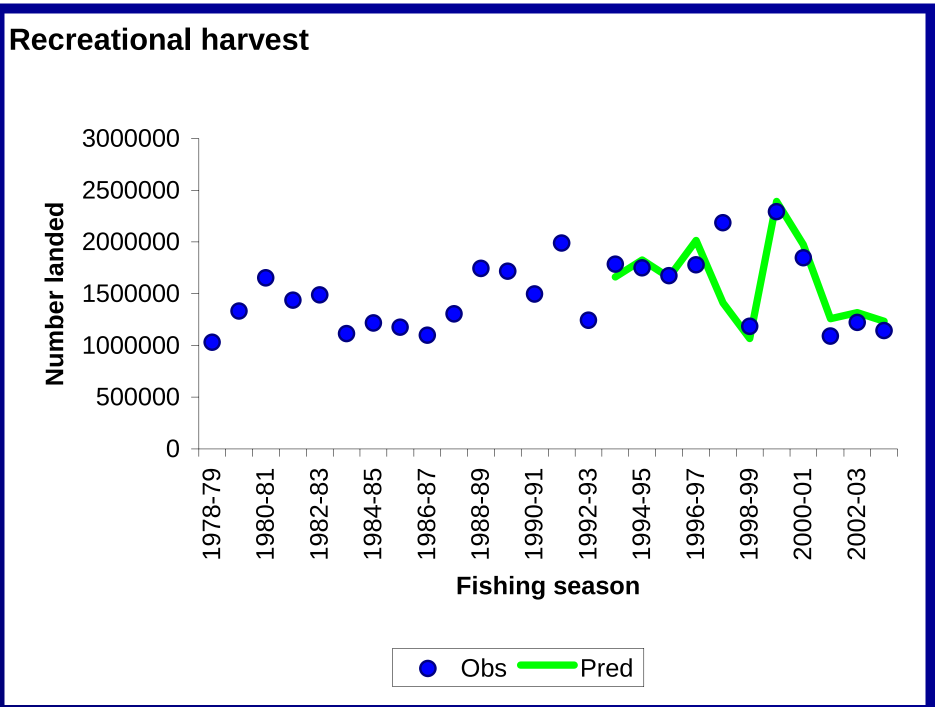
Puerulus catch rate offset two years

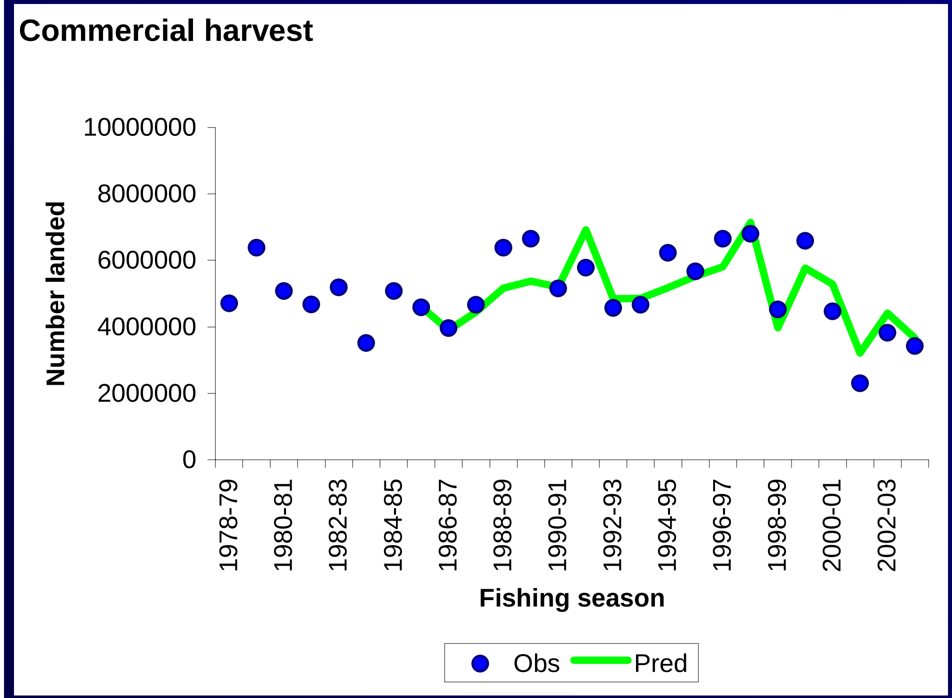
Biscayne National Park creel survey catch rates

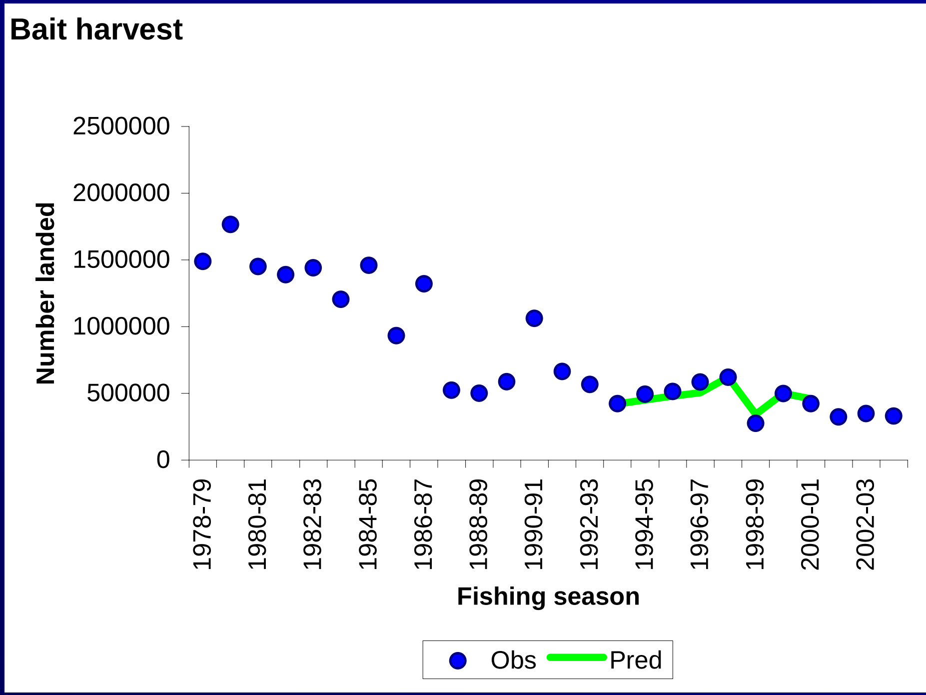
Parameters: Initial number; catchability coefficients for the commercial, bait, and recreational fisheries; indices; plus relative recruitment by fishing year for a potential total of 36 parameters.

Assessment models – DeLury

Fits of DeLury model to harvests by sector



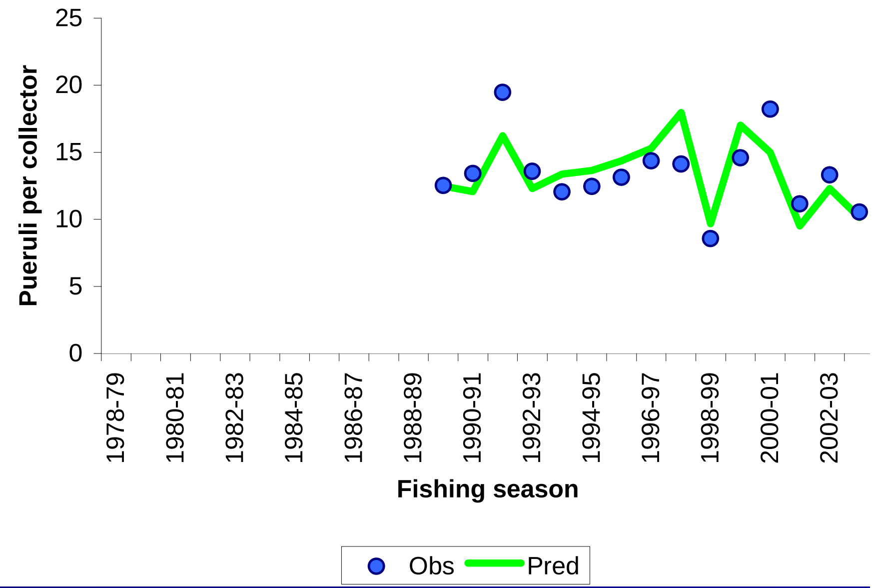




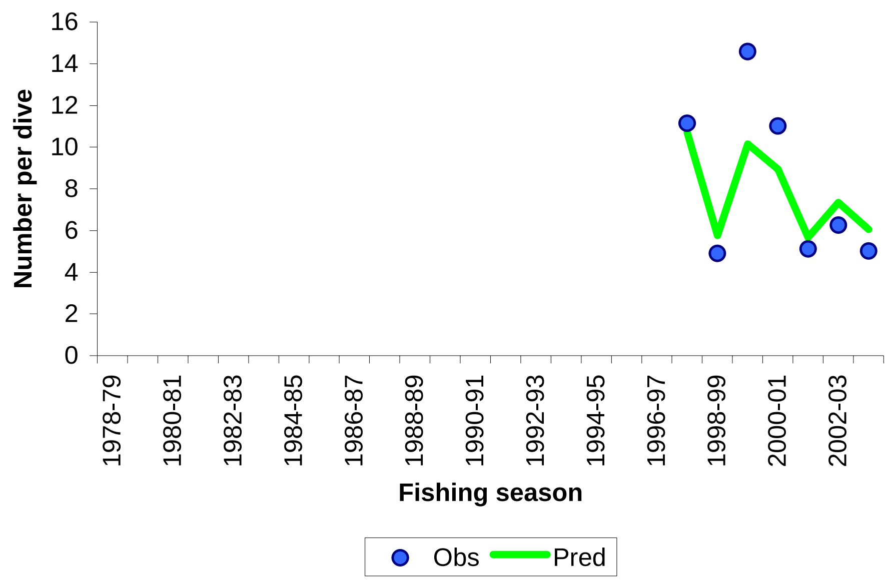
Assessment models – DeLury

Fits of DeLury model to tuning indices by sector. The other three indices were not significant.

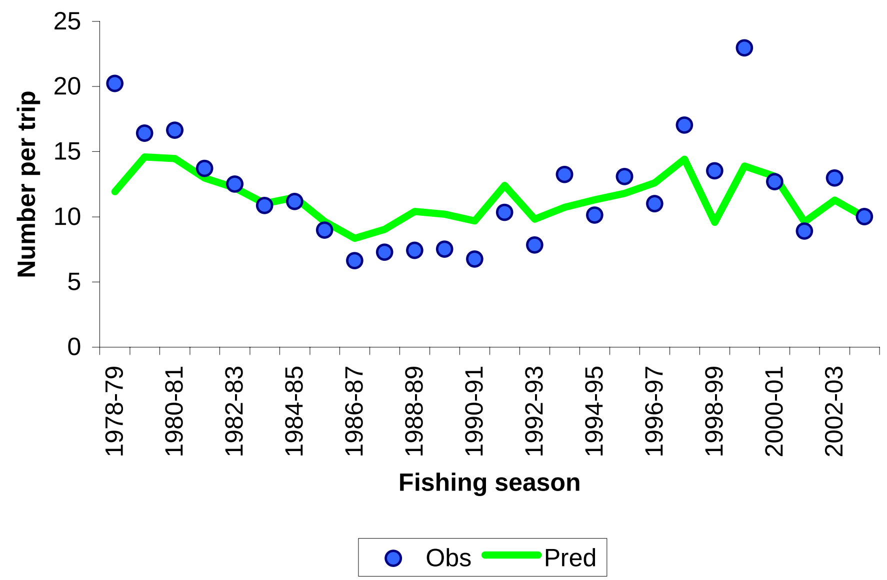
Puerulus offset two years



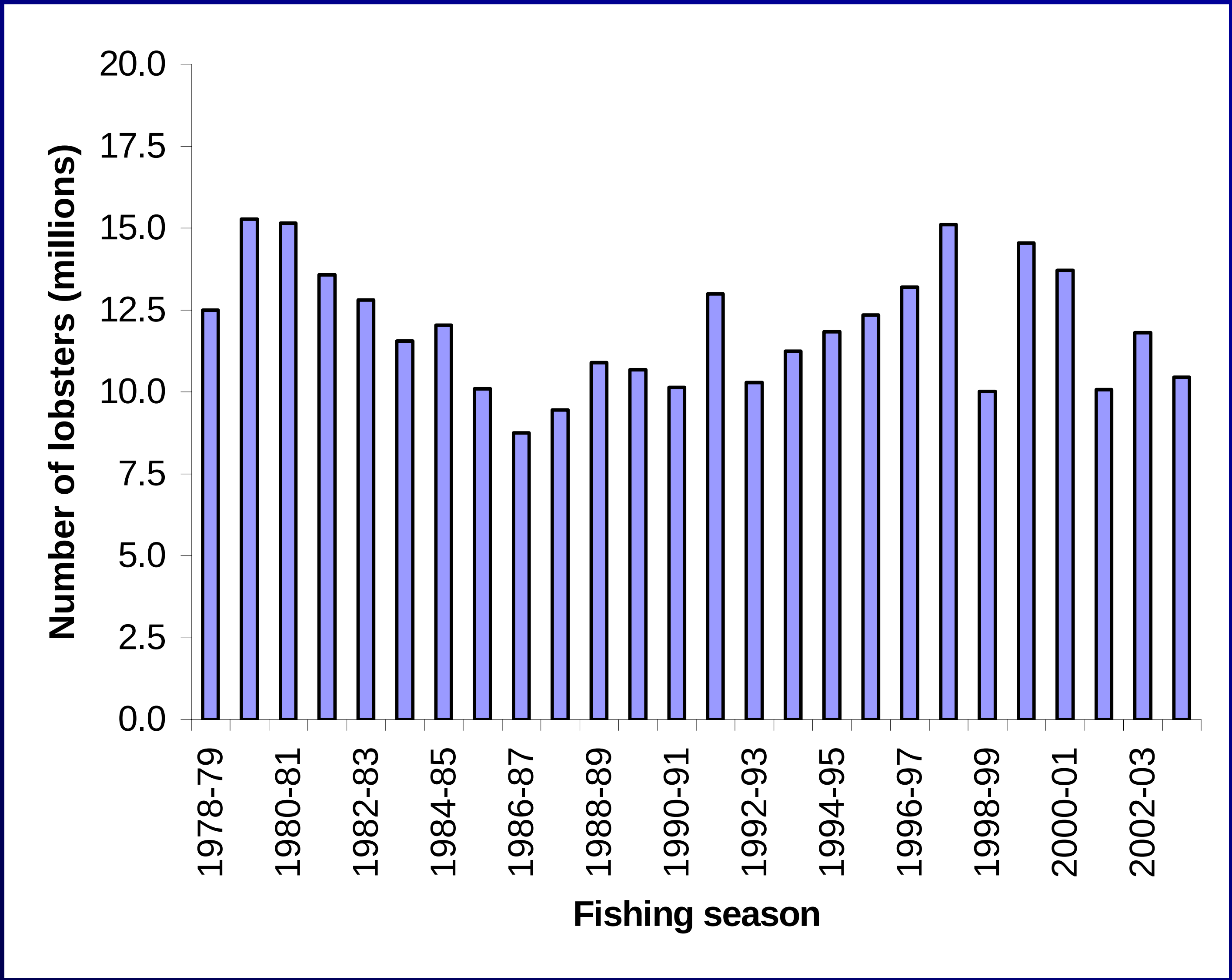
Adult monitoring pre-recruits



Biscayne National Park Creel Survey

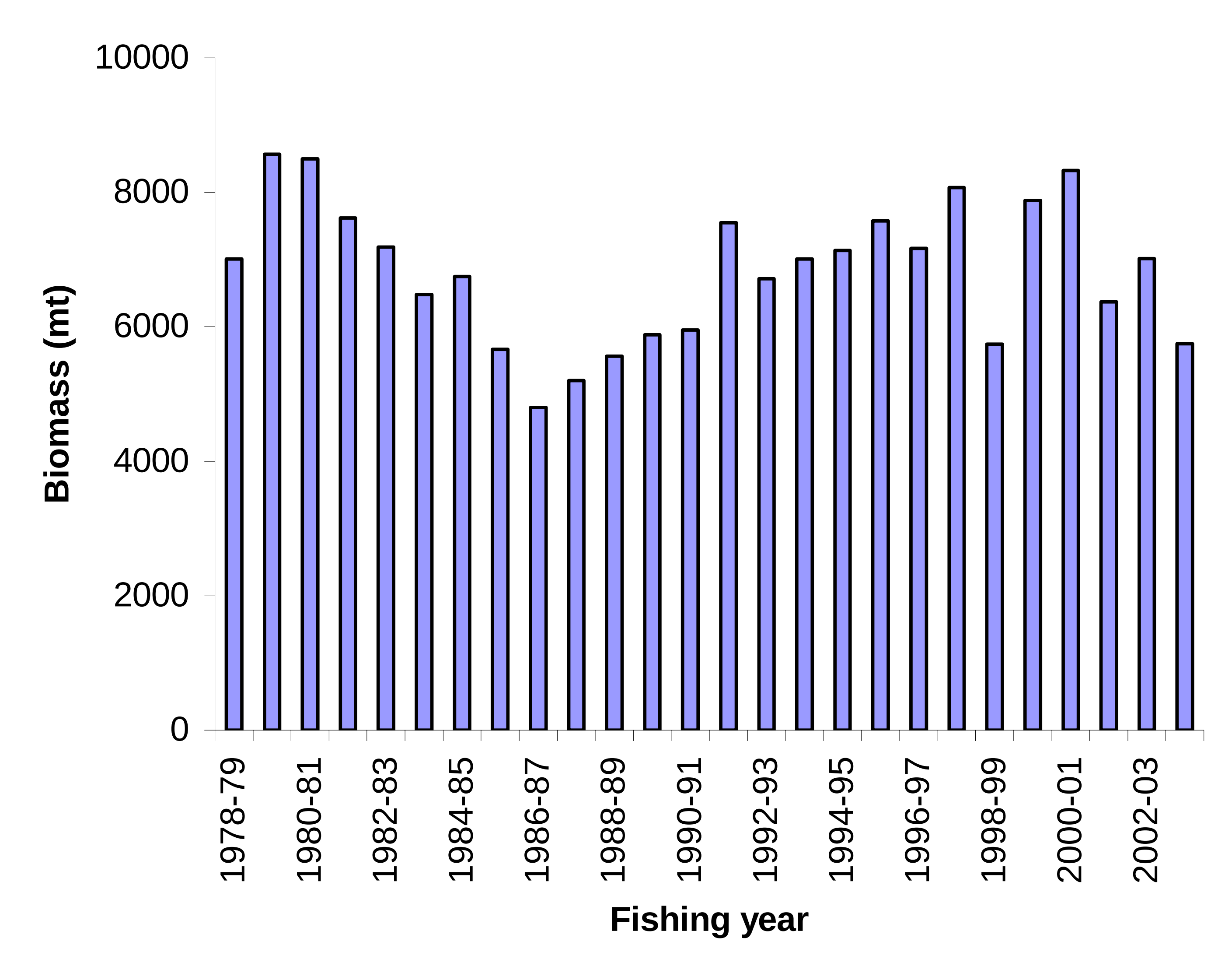


Assessment models – DeLury



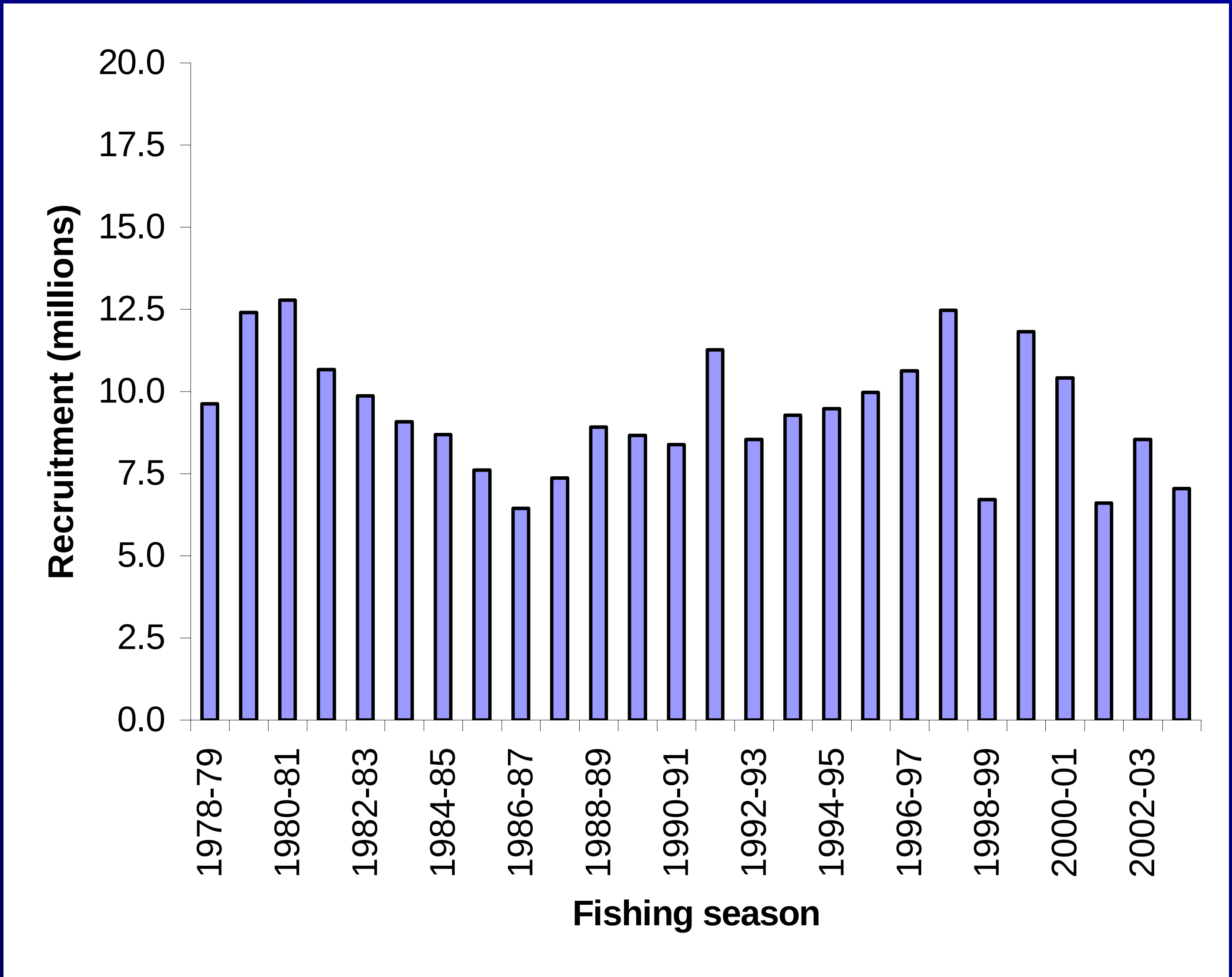
Estimated numbers of lobsters by fishing year from DeLury model

Assessment models – DeLury



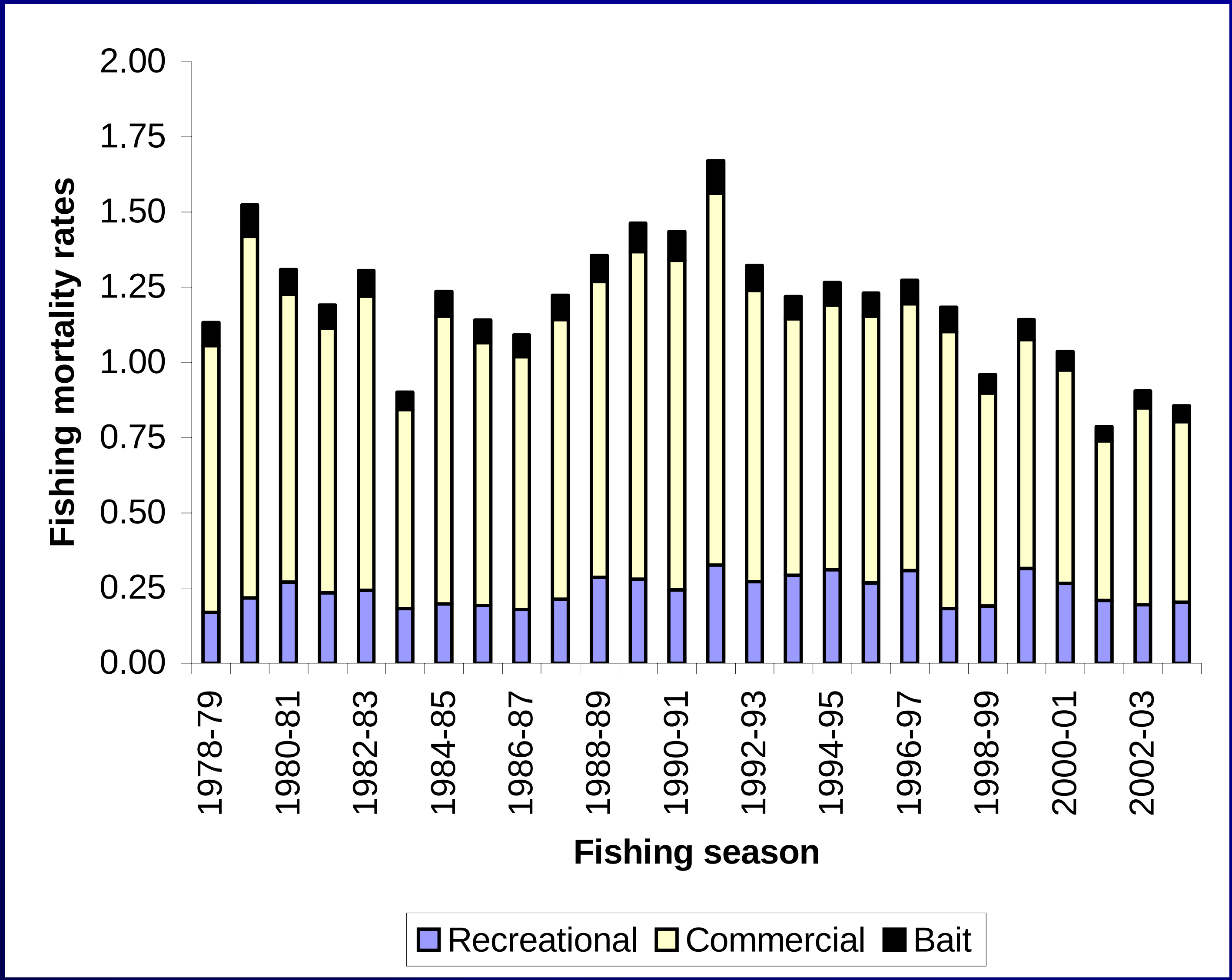
Estimated biomass by fishing year from DeLury model

Assessment models – DeLury



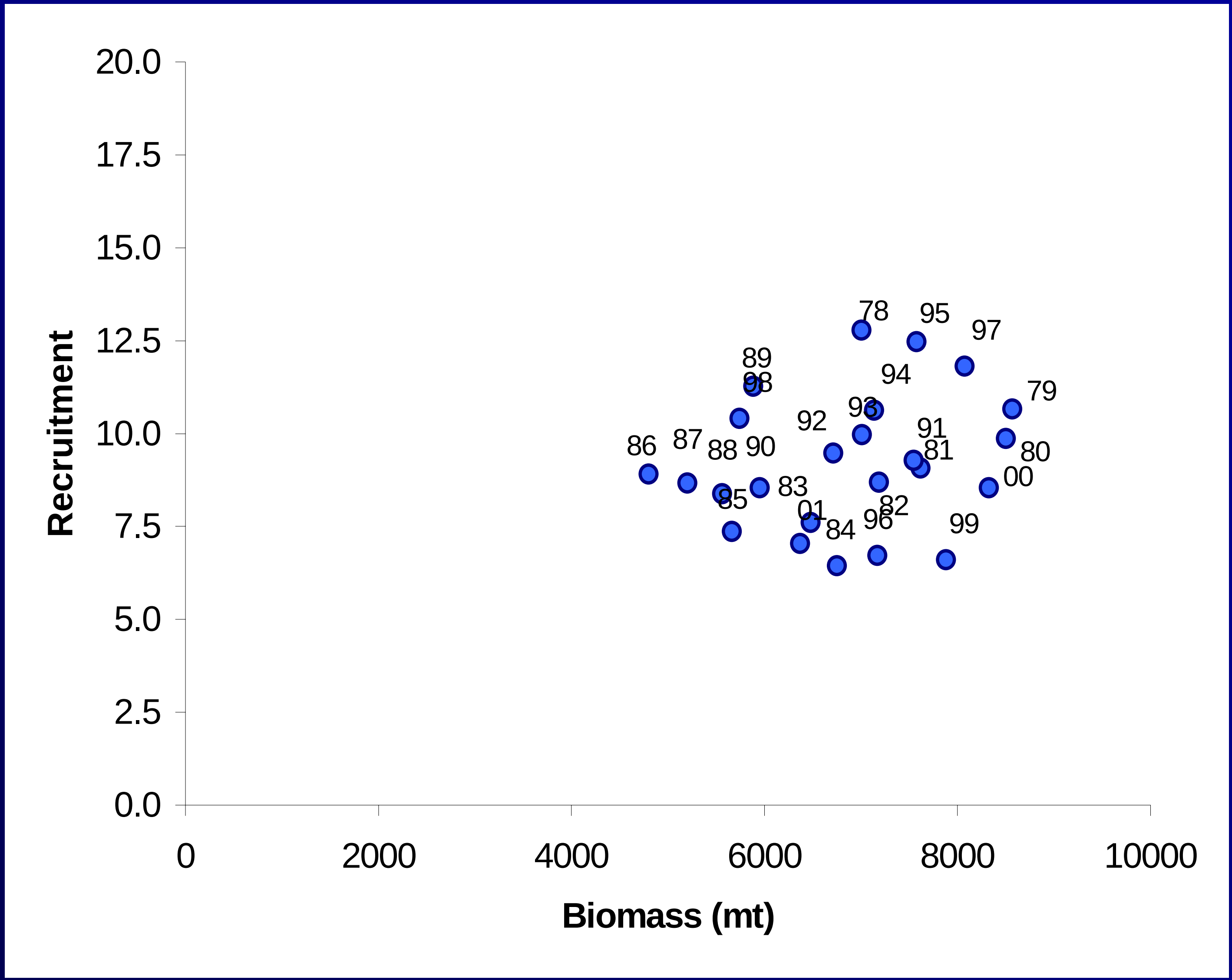
Estimated numbers of recruitment by fishing year from DeLury model

Assessment models – DeLury



Estimated fishing mortality rates by fishery and fishing year from DeLury model

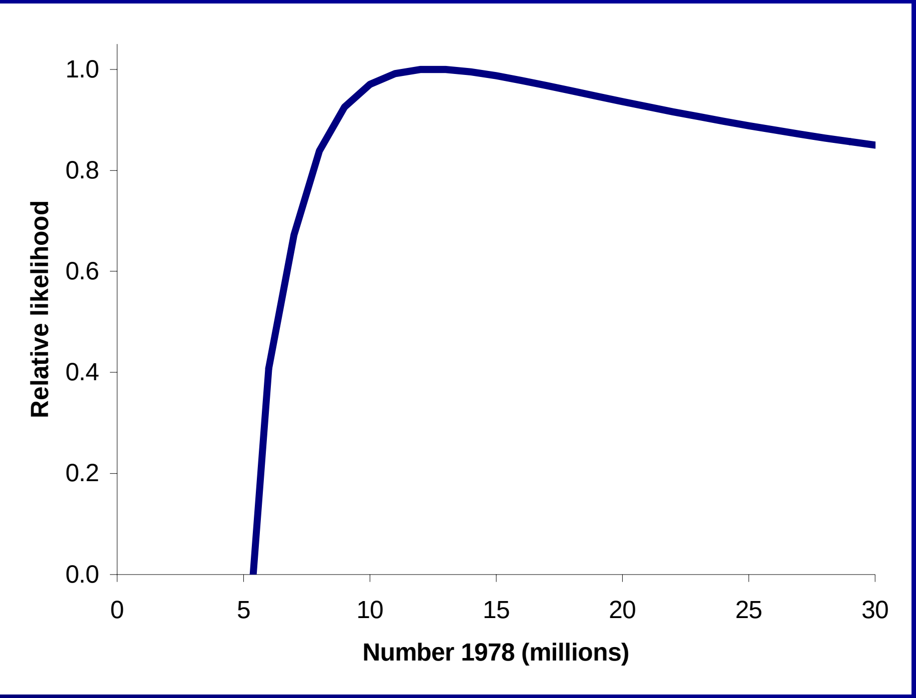
Assessment models – DeLury

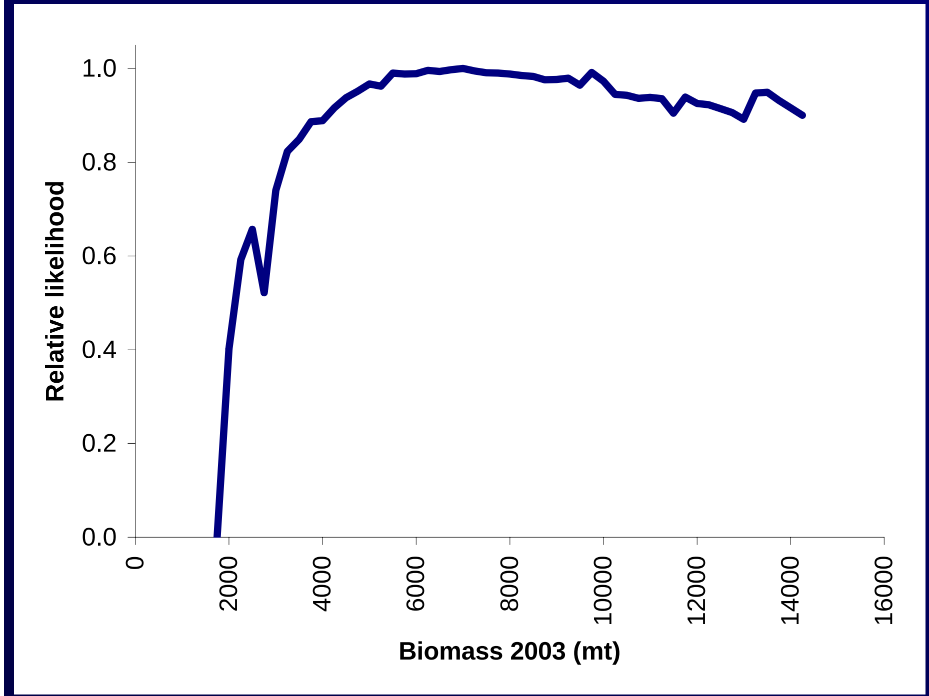


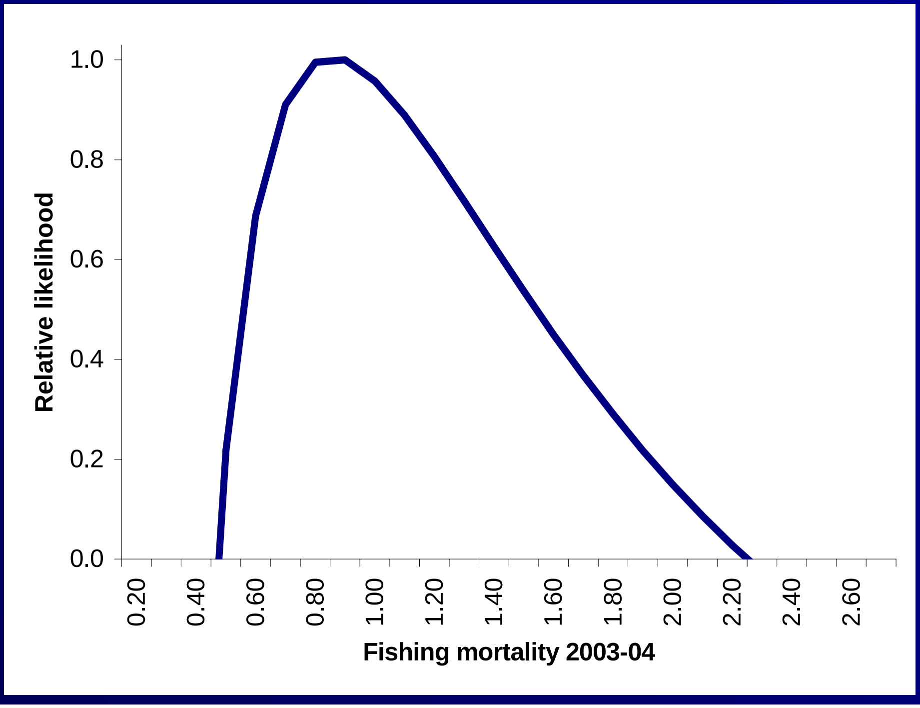
Estimated biomass and recruitment two years later from DeLury model. Numbers are the biomass fishing years.

Assessment models – DeLury

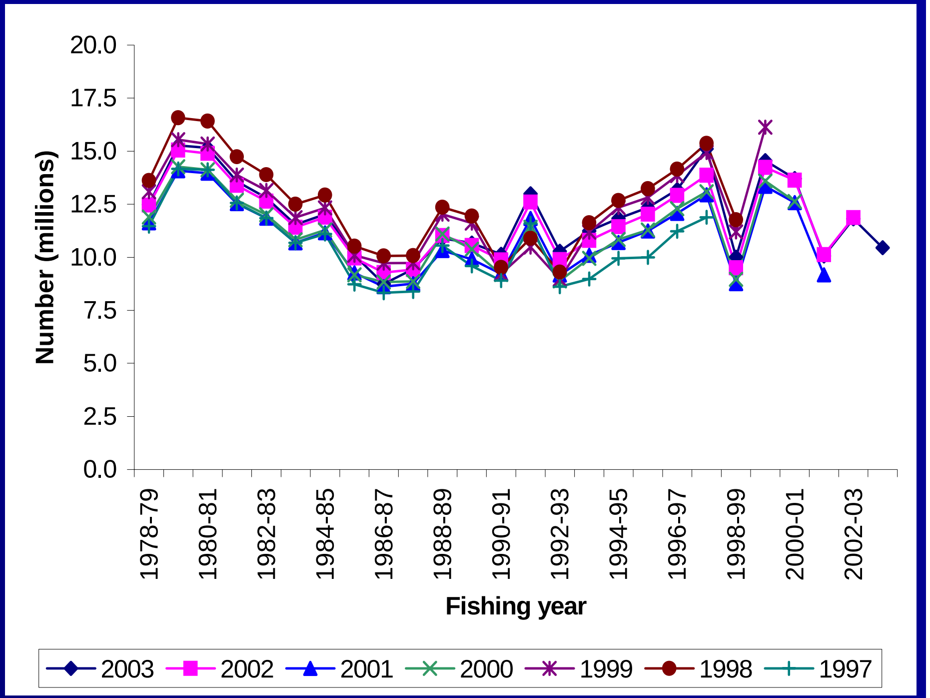
Likelihood profiles
from DeLury model



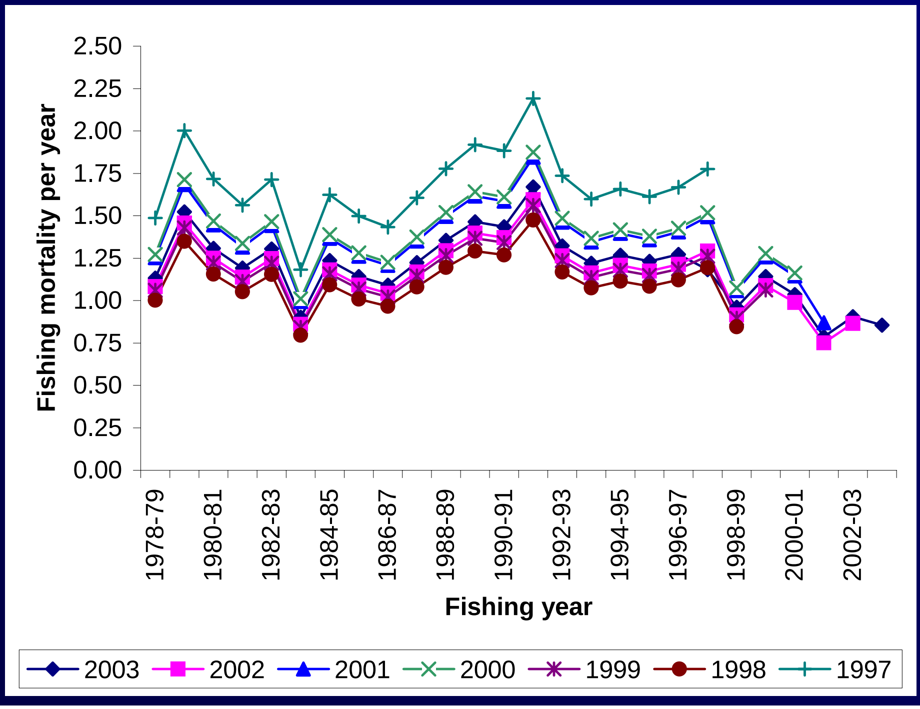


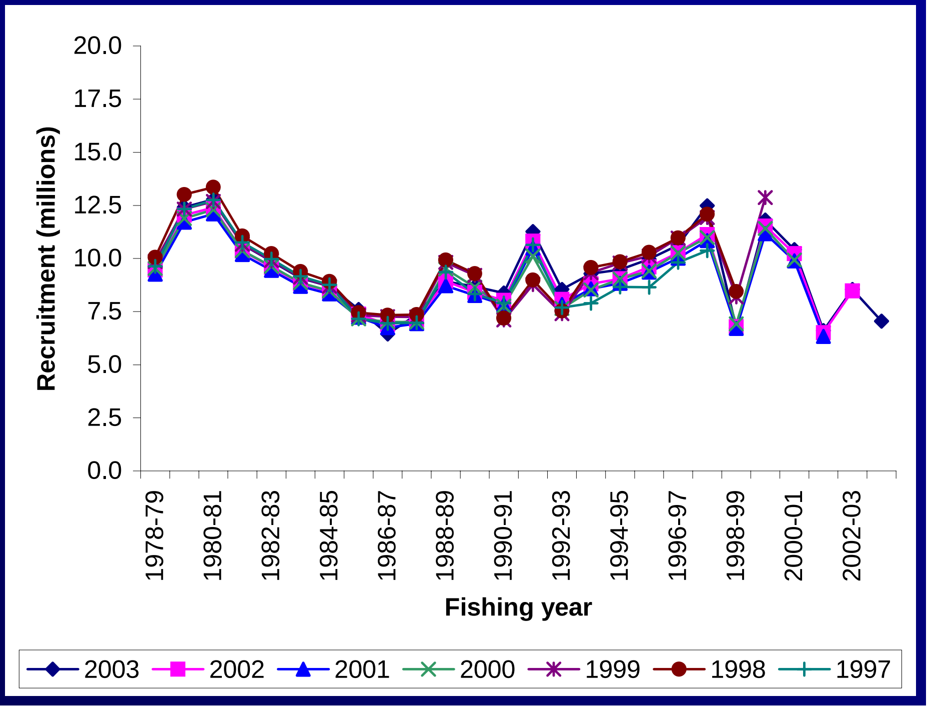


Assessment models – DeLury



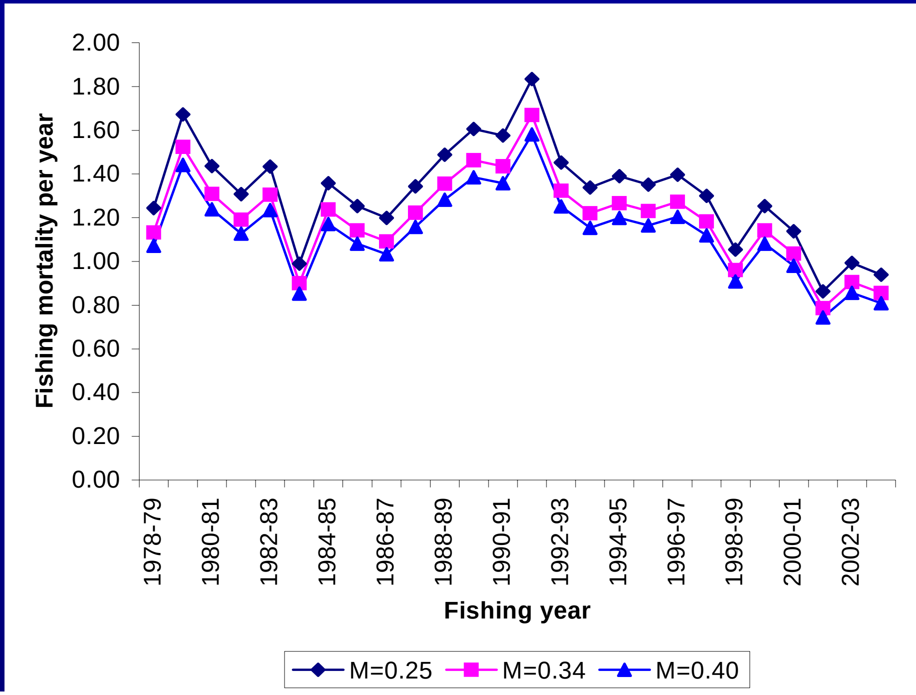
Retrospective runs from DeLury model

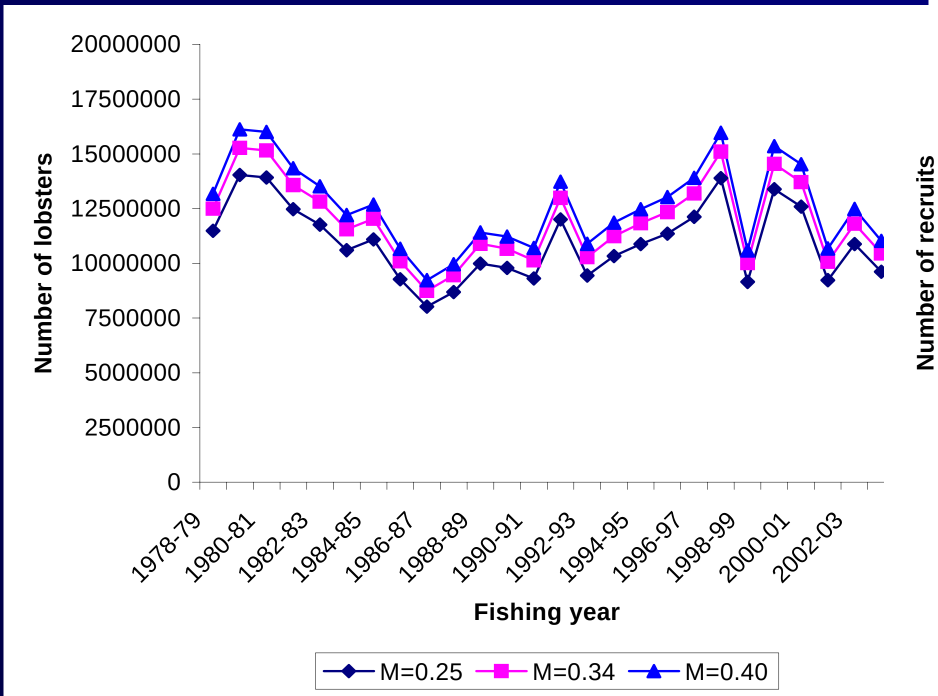


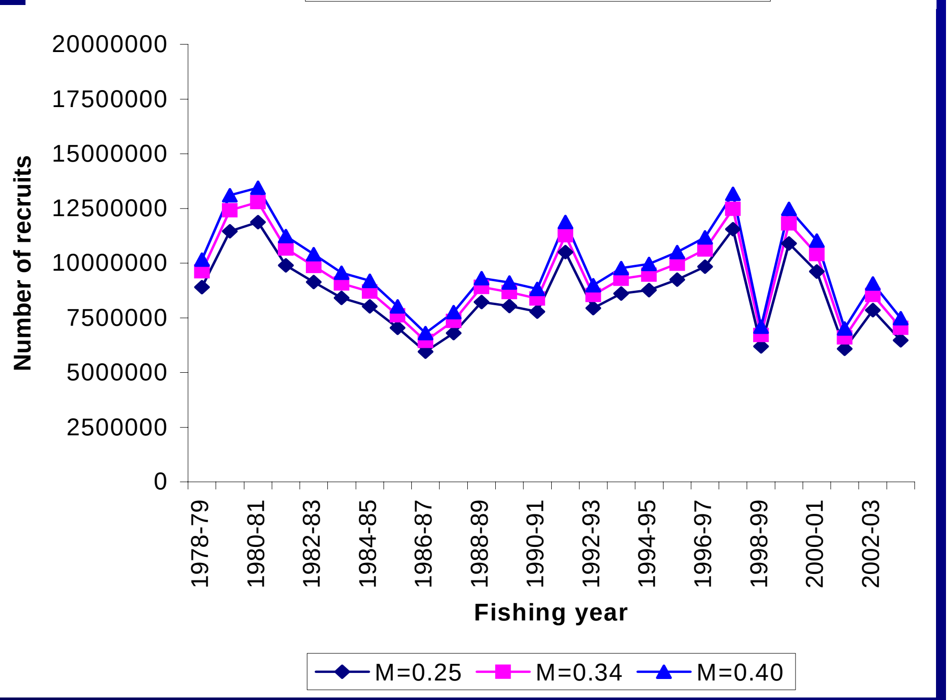


Assessment models – DeLury

DeLury results with alternative natural mortality rates.







Assessment models – age structured

- Age-based models that were presented at Stock Assessment Workshop
  - Robson-Chapman catch curve
  - Untuned Virtual Population Analysis
  - Tuned VPA (FADAPT 3.0)
  - Integrated Catch-at-age
  - Age structured population analysis (ASAP)

Assessment models – age structured Catch curve

Basis	Ages	S	M Per year	F Per year
Tagging	3 - 11	0.42	0.34	0.52
Lipofuscin Keys	2 - 8	0.31	0.50	0.67
Lipofuscin Tortugas	2 - 5	0.14	0.75	1.59

Robson-Chapman catch curves using 1999-2003 average numbers of lobsters harvested.

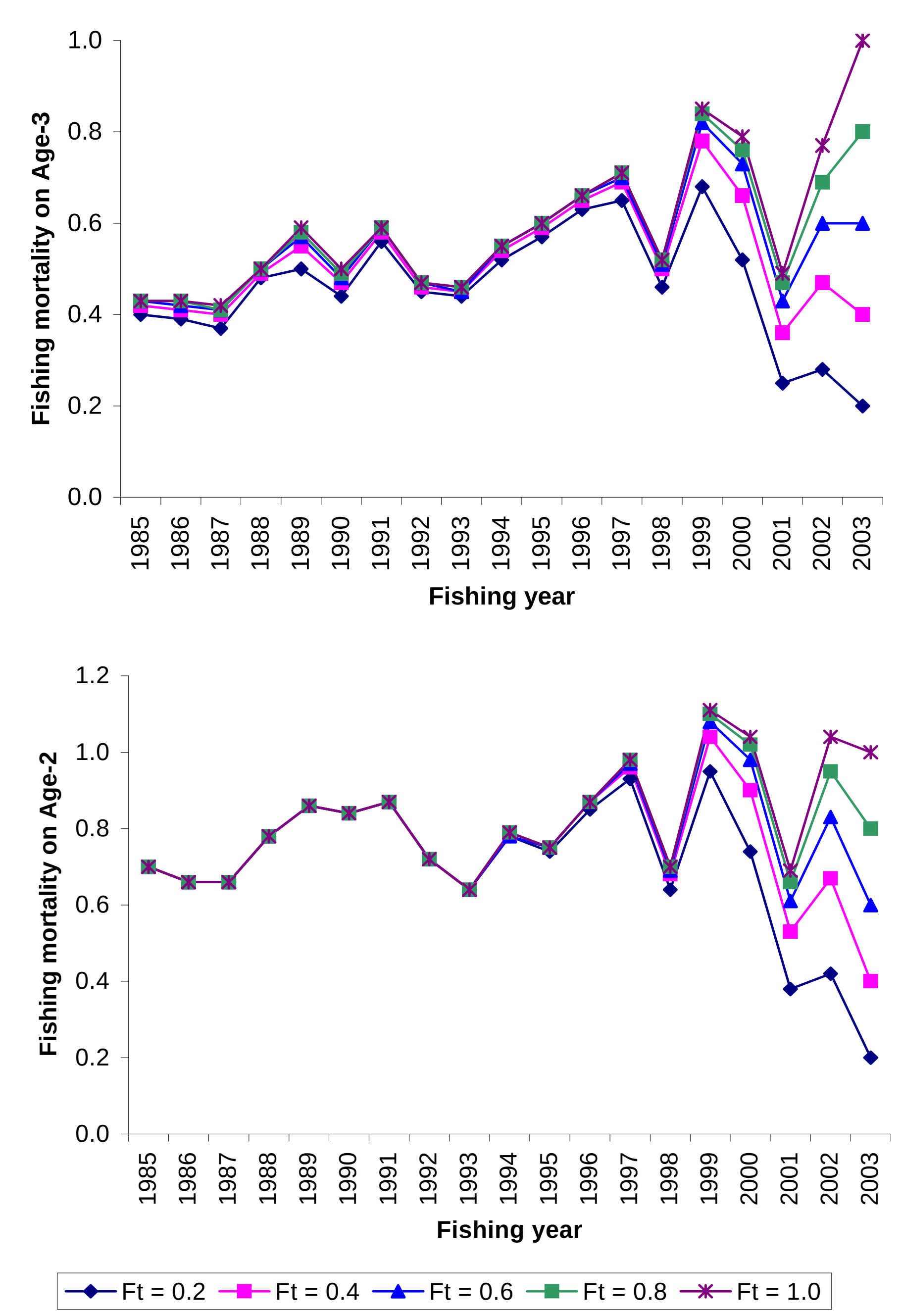
Assessment models – age structured

Untuned VPA

Tagging

Untuned virtual population analyses with various terminal fishing mortality rates

Lipofuscin - Keys



Assessment models – age structured ICA

Integrated catch-at-age (ICA)

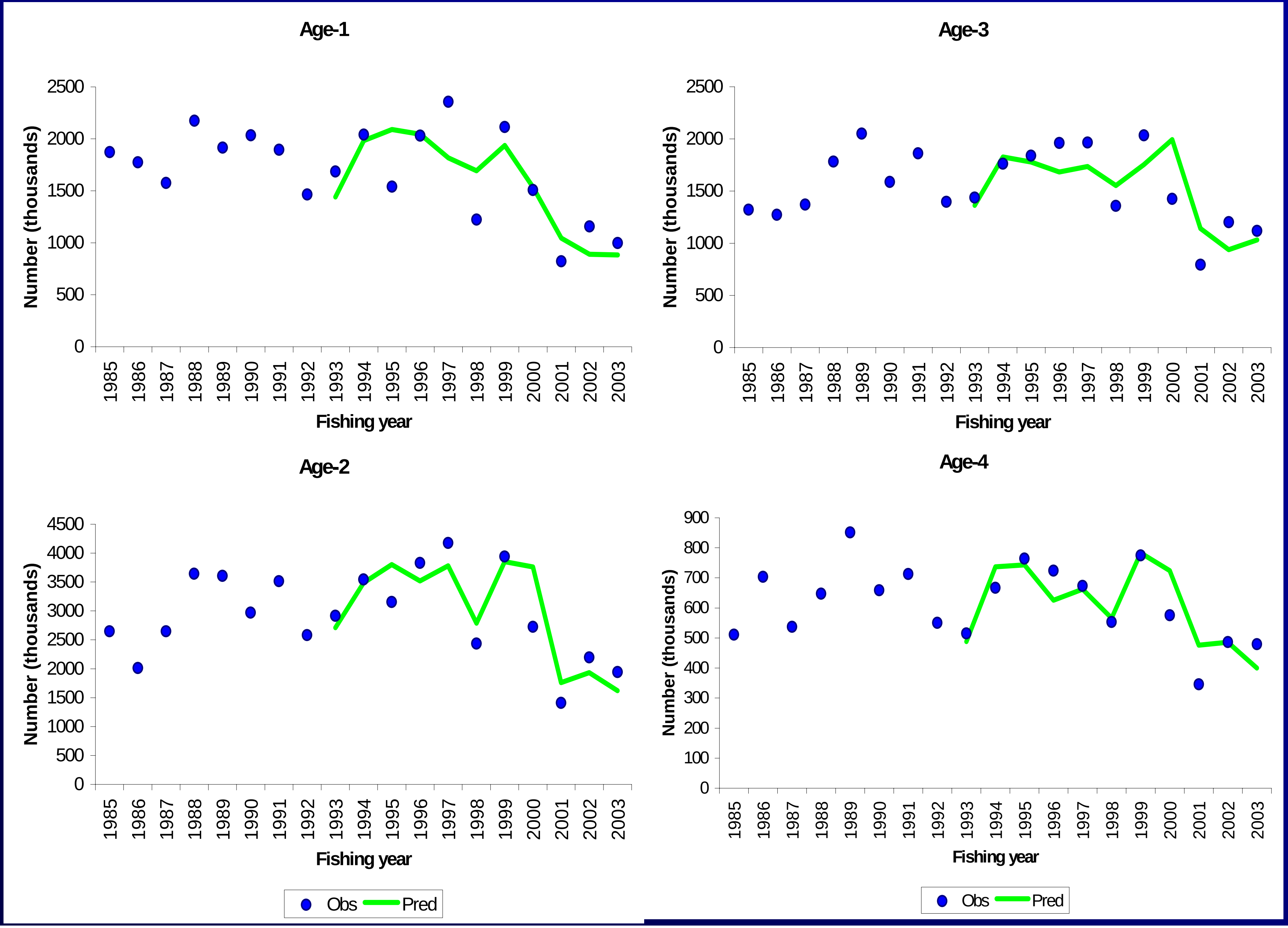
Uses a single catch-at-age and all six tuning indices

Does not assume that catch-at-age is known without error.

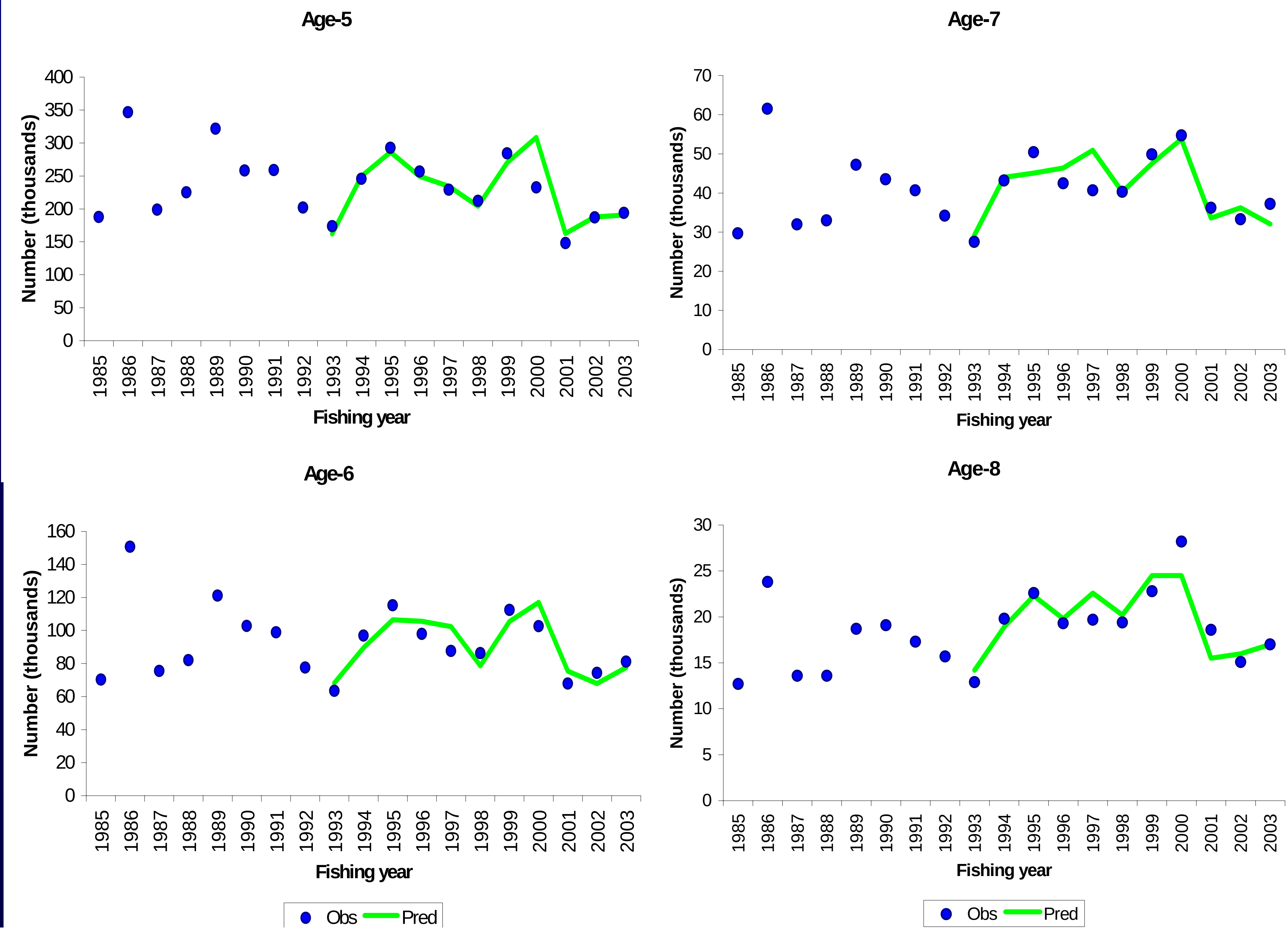
Statistical model uses a backward projection.

The model was configured with constant selectivity for 1993-2003 and allowed earlier years to be estimated in a manner like ADAPT.

Assessment models – age structured ICA

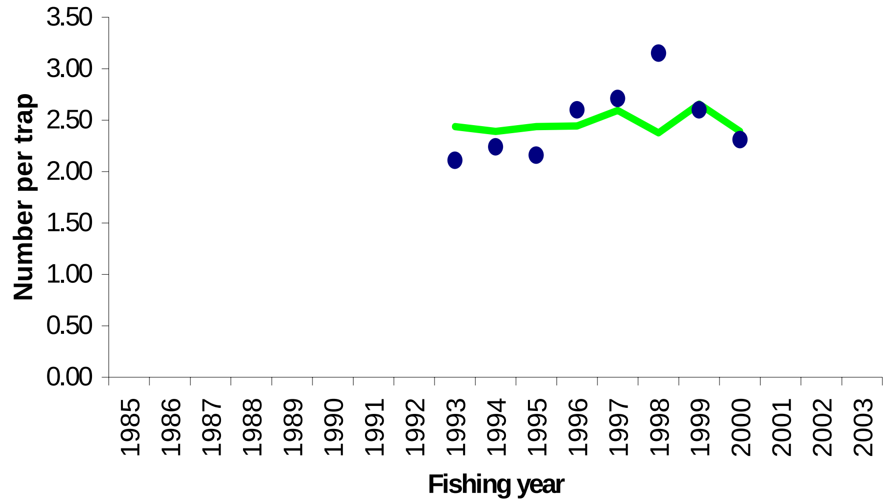


Assessment models – age structured ICA

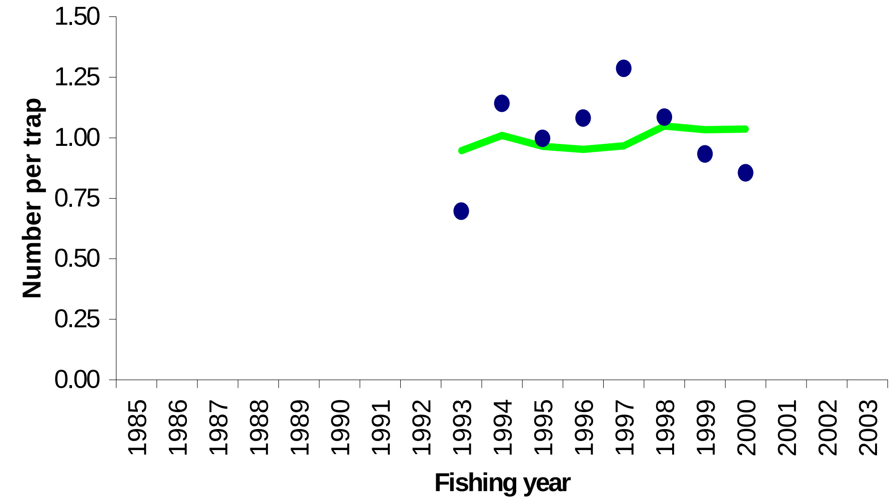


Assessment models – age structured ICA

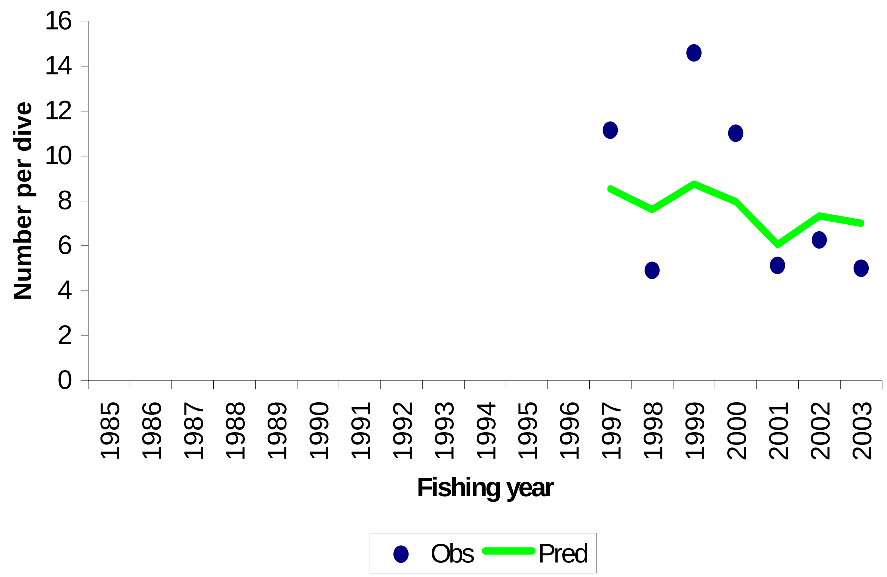
Observer pre-recruits



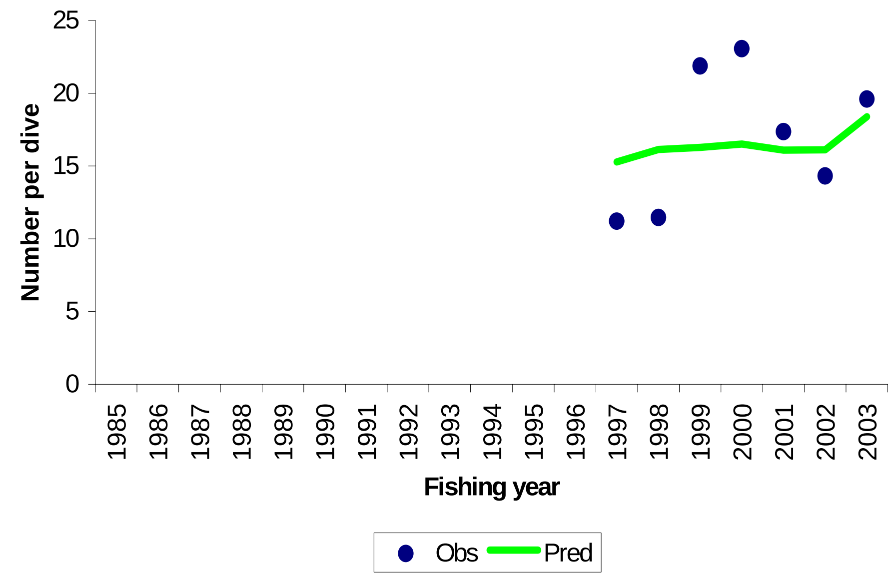
Observer legal sizes



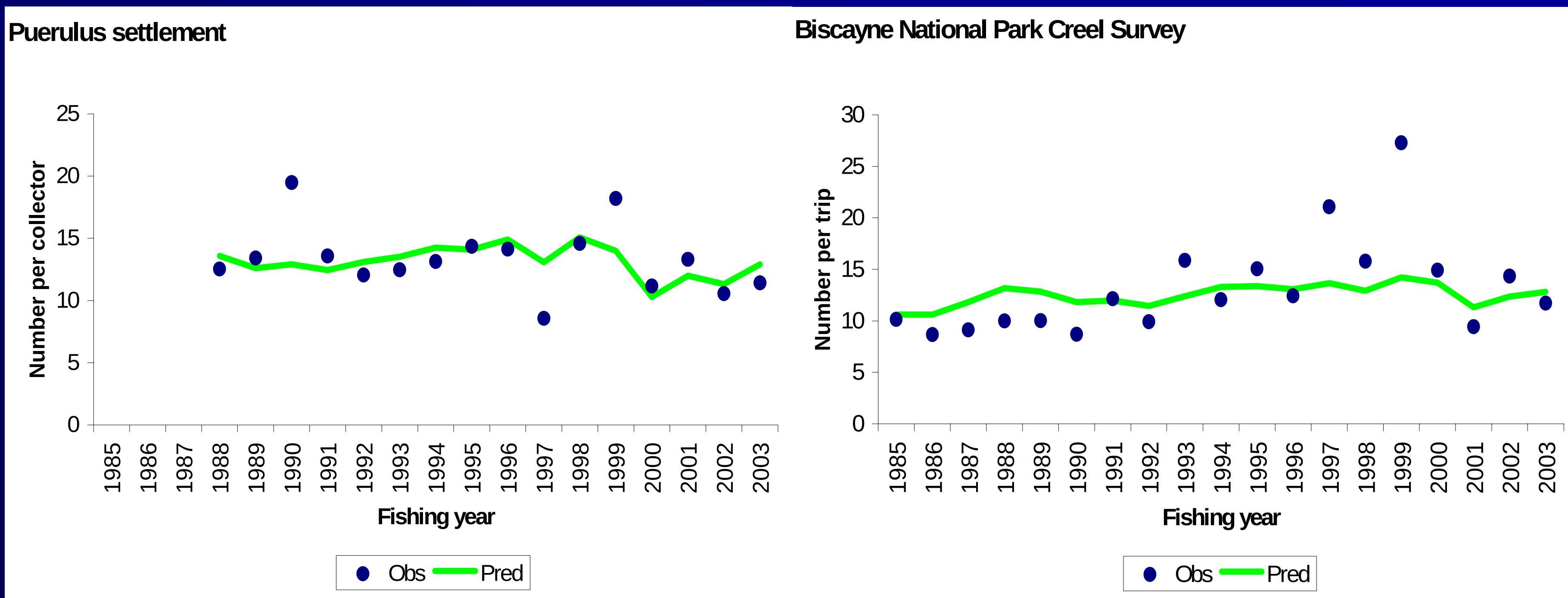
Adult monitoring pre-recruits



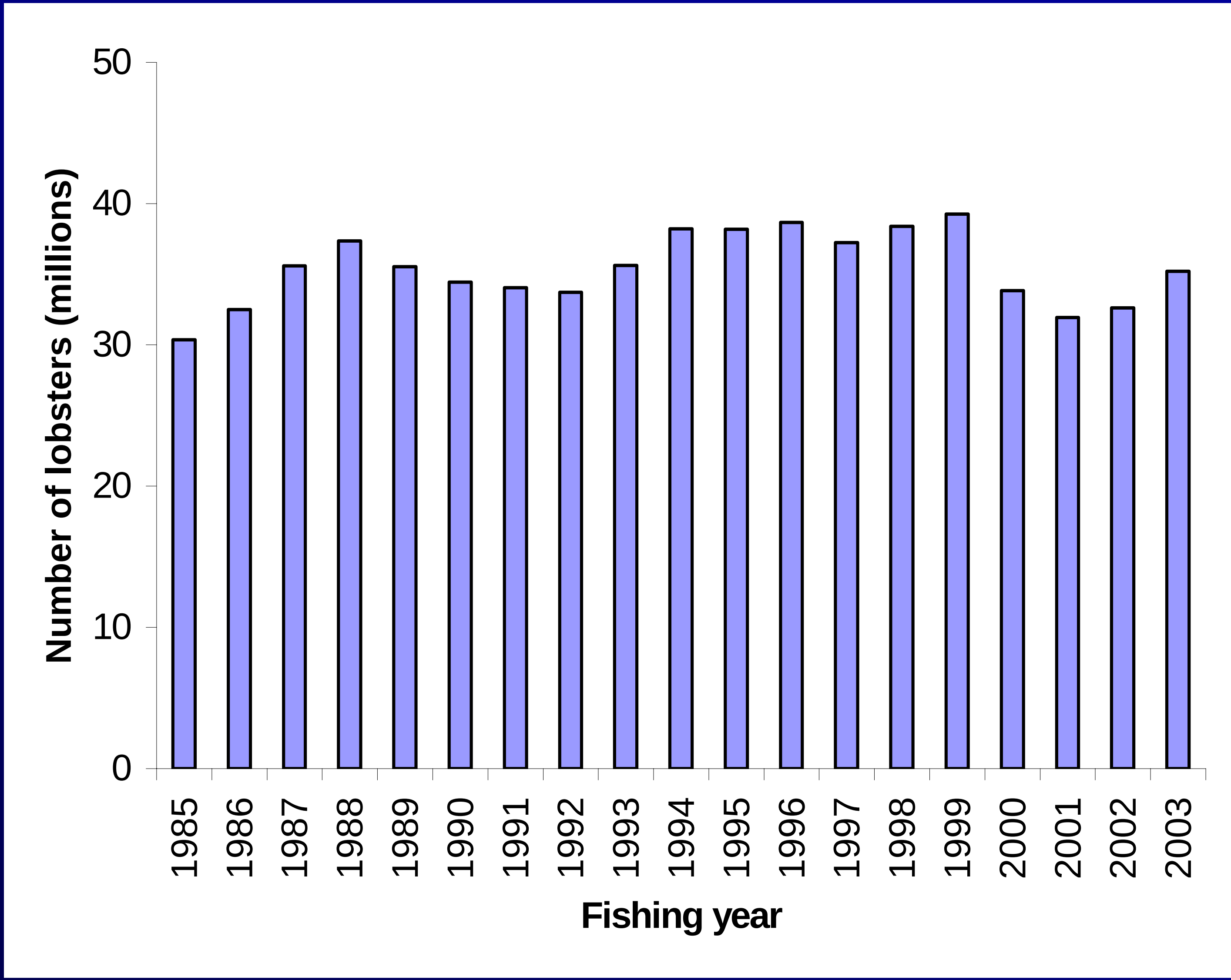
Adult monitoring legal sizes



Assessment models – age structured ICA

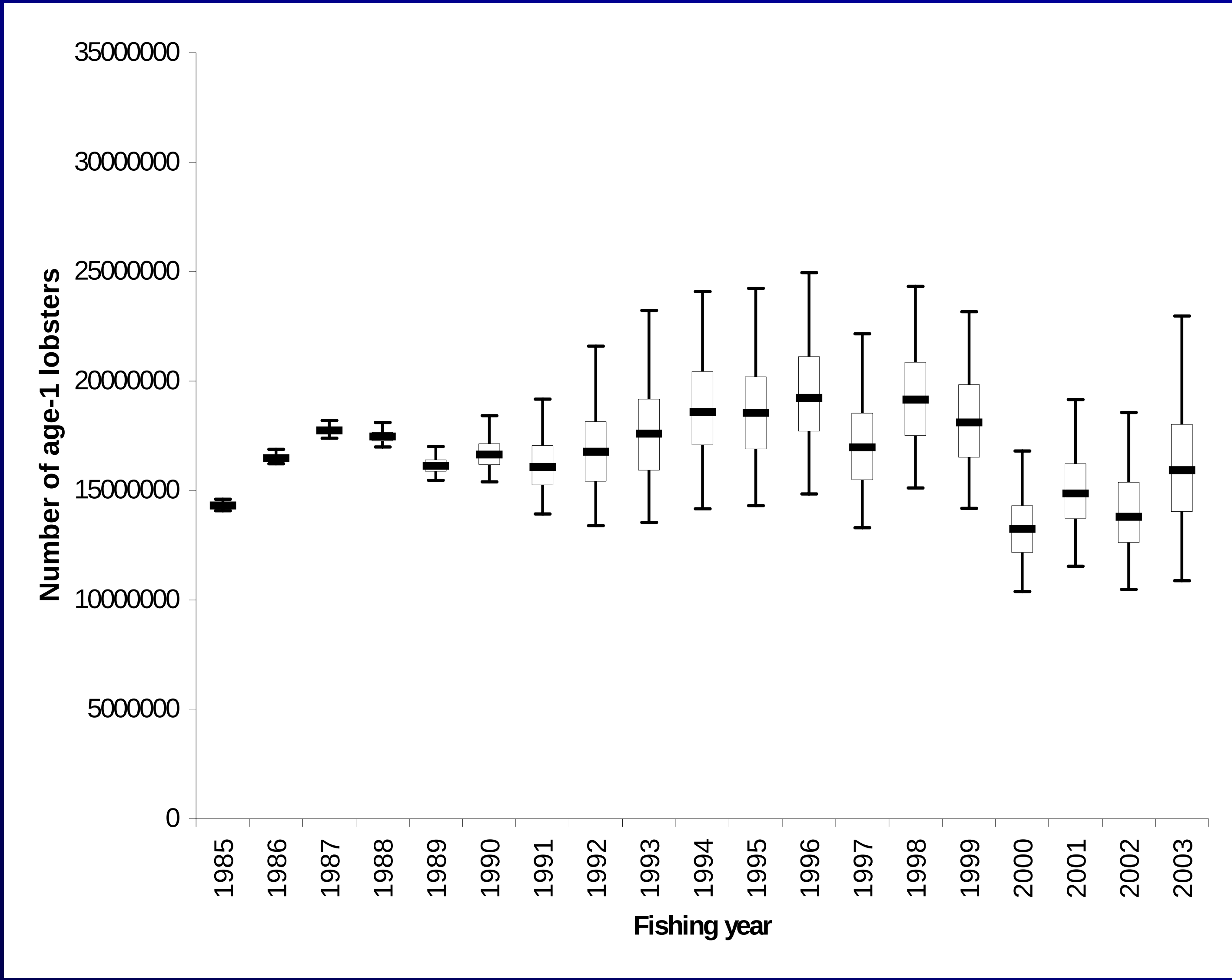


Assessment models – age structured ICA



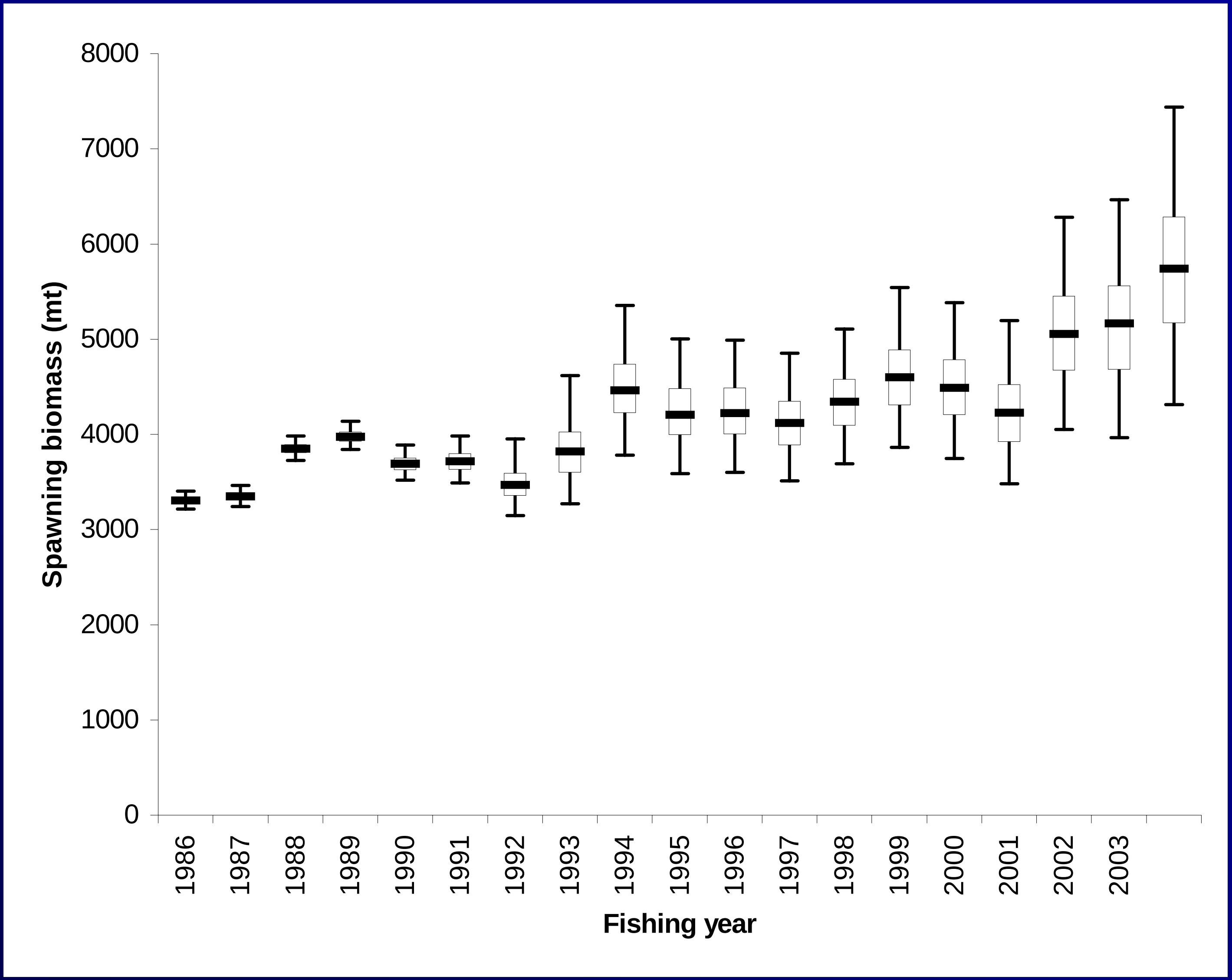
Numbers of lobsters by fishing year

Assessment models – age structured ICA



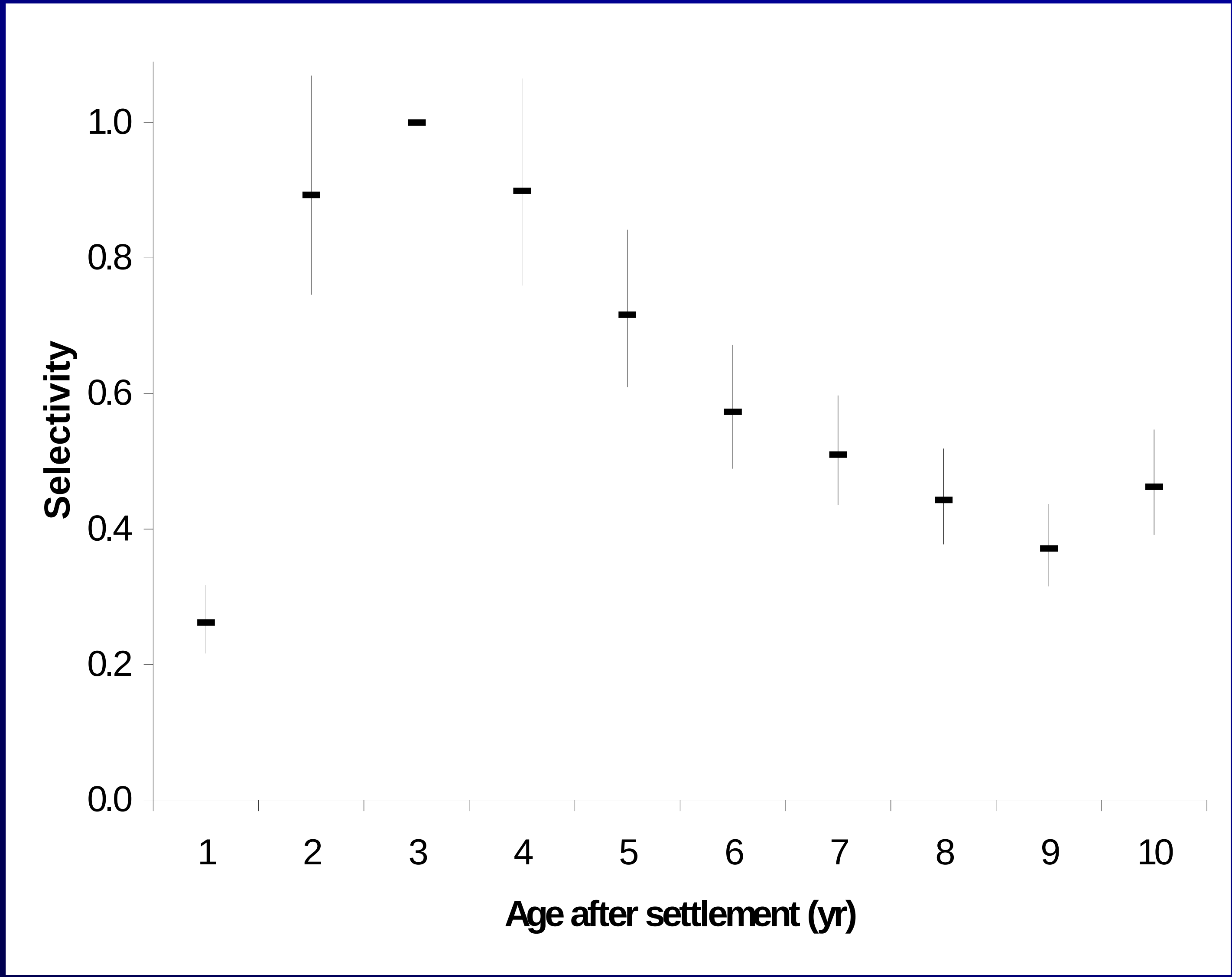
Recruitment by fishing year showing 95% confidence interval, inter-quartiles, and medians from 1000 Monte Carlo runs

Assessment models – age structured ICA



Spawning biomass by fishing year

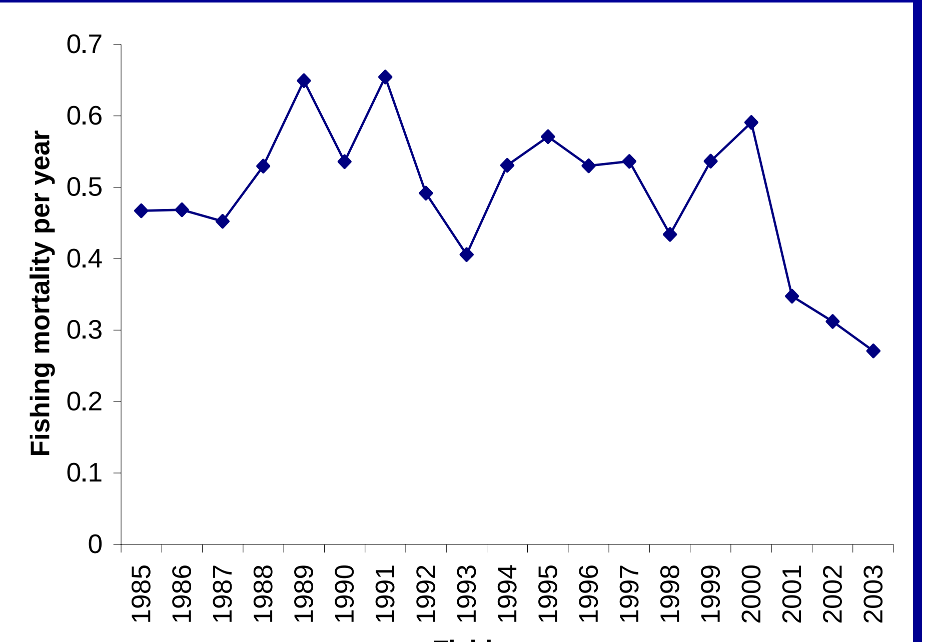
Assessment models – age structured ICA



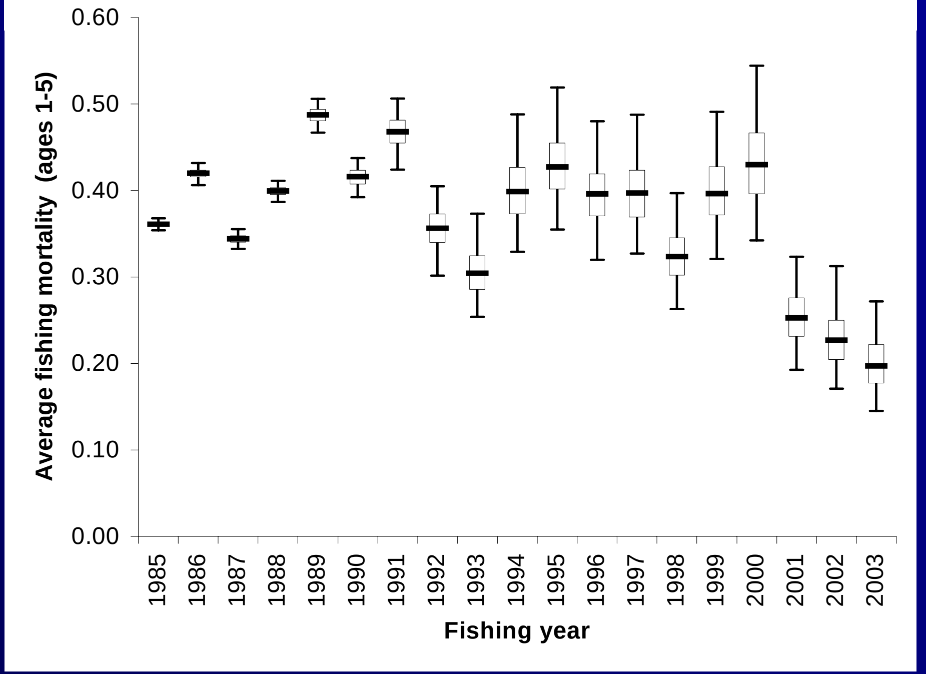
Selectivity by age for the period 1993-94 through 2003-04

Assessment models – age structured ICA

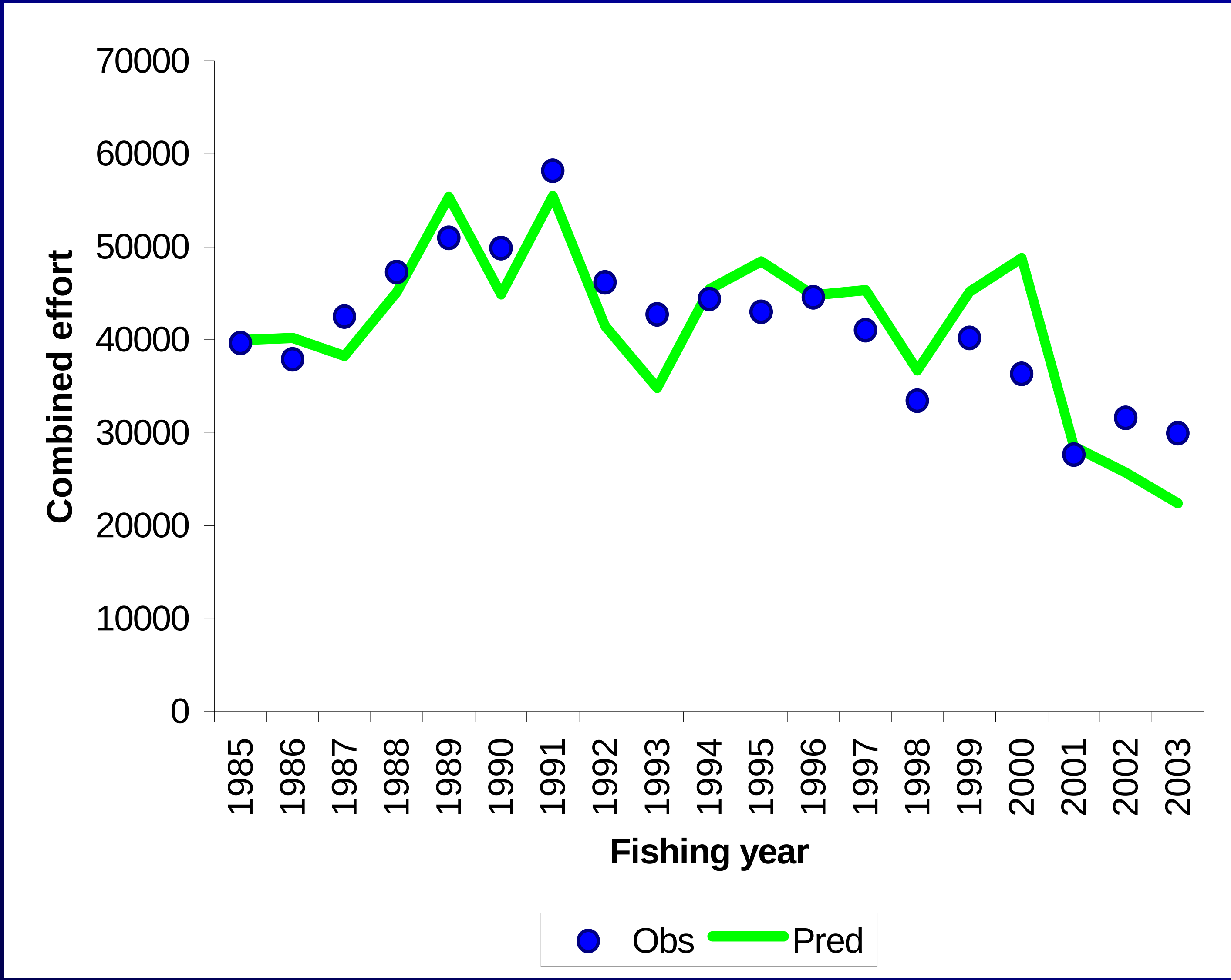
Fishing mortality rates on age-3 (fully recruited) lobsters by fishing year



Average fishing mortality rates on age 1-5 lobsters by fishing year. Variability came from 1000 Monte Carlo runs using the covariance matrix. Vertical lines are 95% confidence intervals, boxes are inter-quartiles, and horizontal lines are medians.

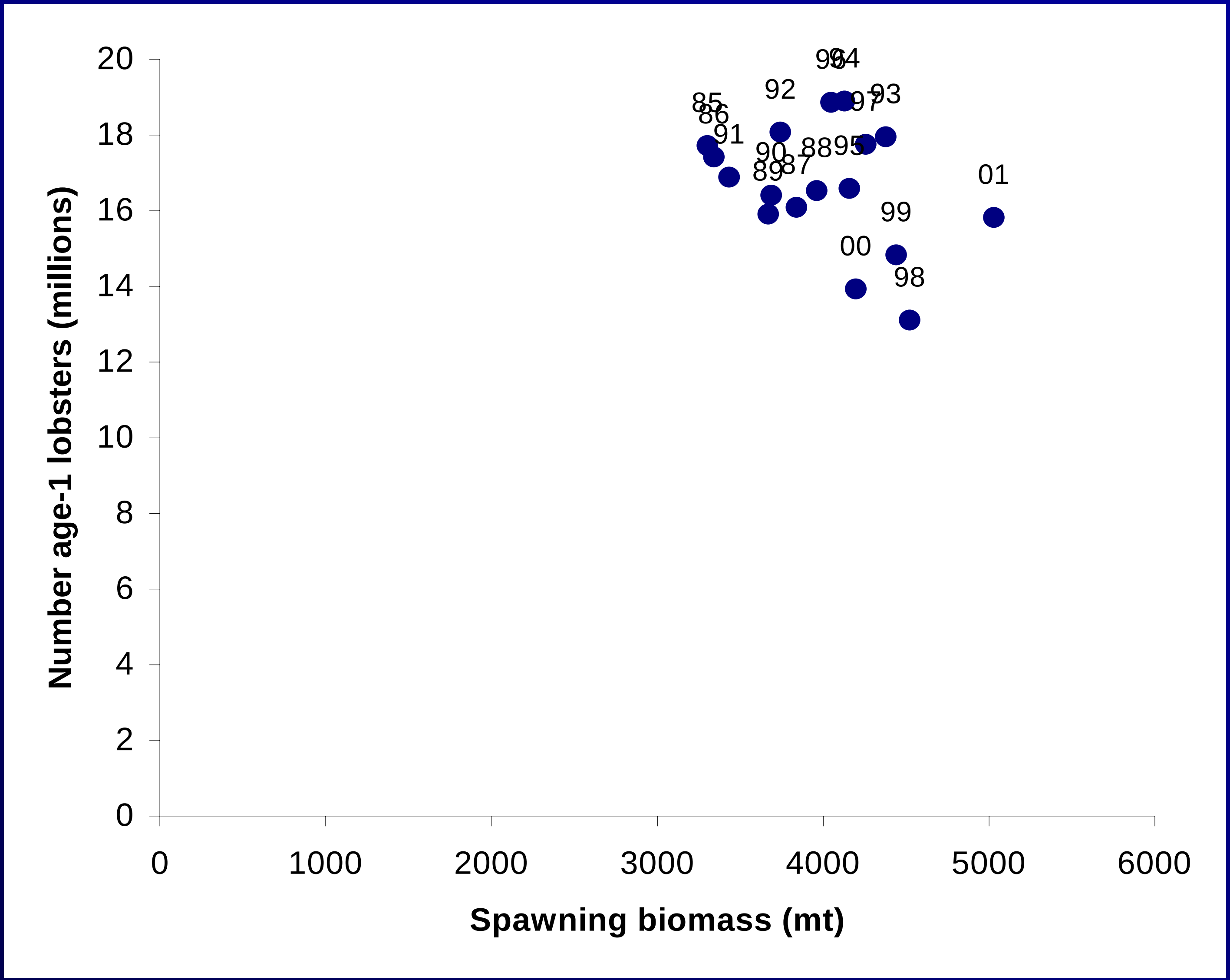


Assessment models – age structured ICA



Observed and predicted combined effort expressed in commercial trips

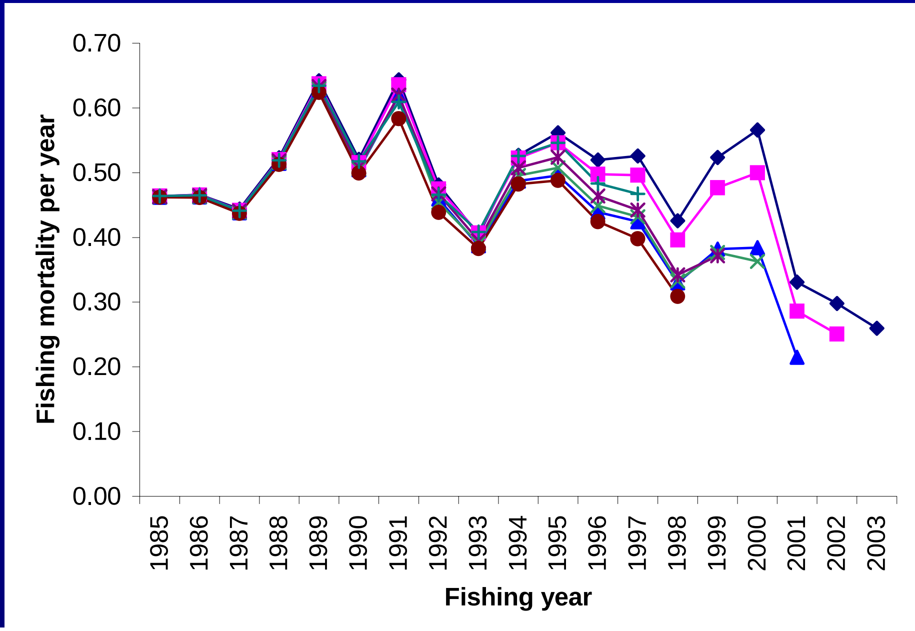
Assessment models – age structured ICA

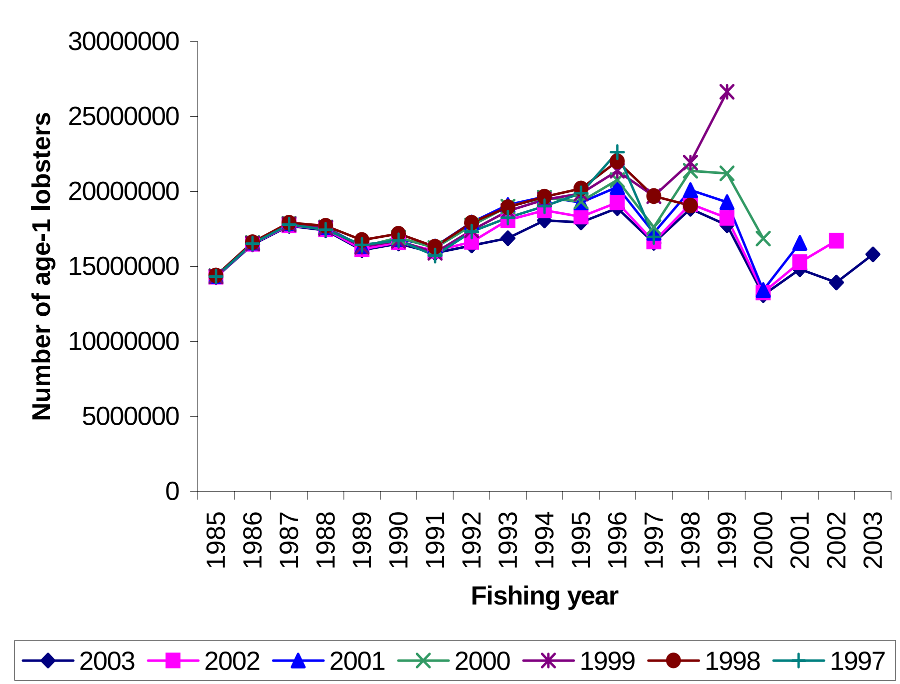


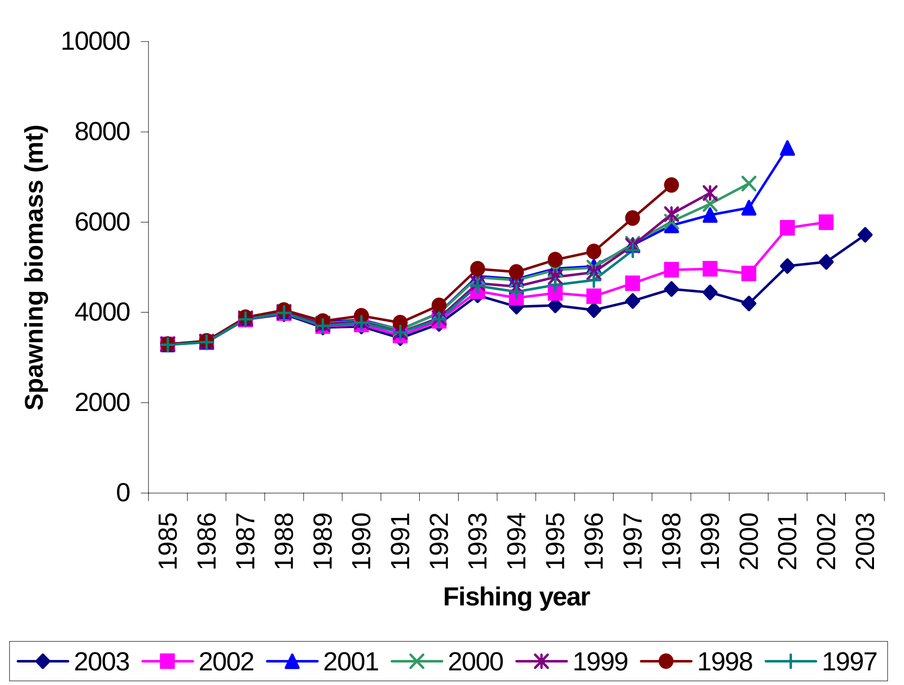
Spawning biomass and recruitment offset two years

Assessment models – age structured ICA

Retrospective analysis using terminal fishing years of 1997-98 through 2002-03



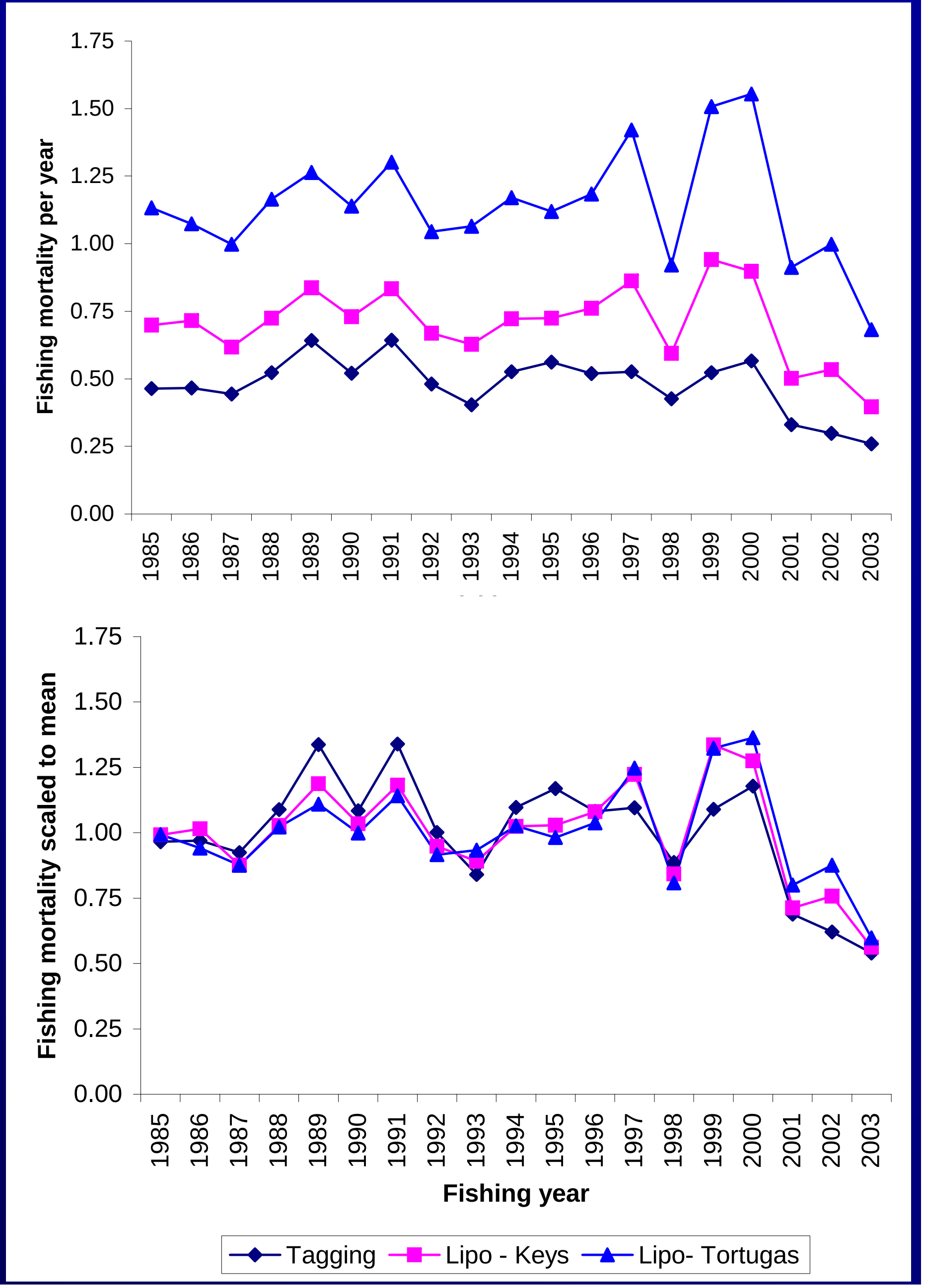




Assessment models – age structured ICA

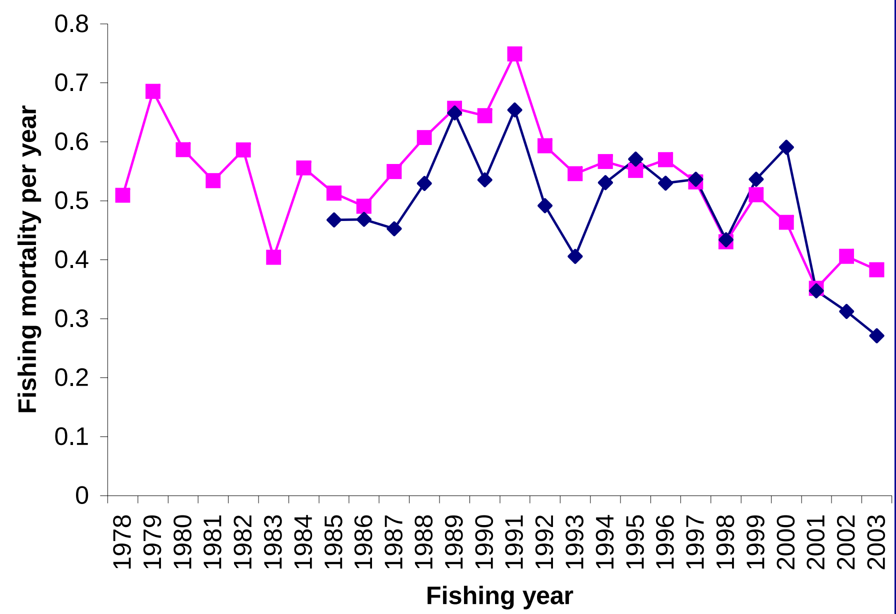
Fishing mortality rates estimated with lipofuscin based growth models

Rates scaled to their means



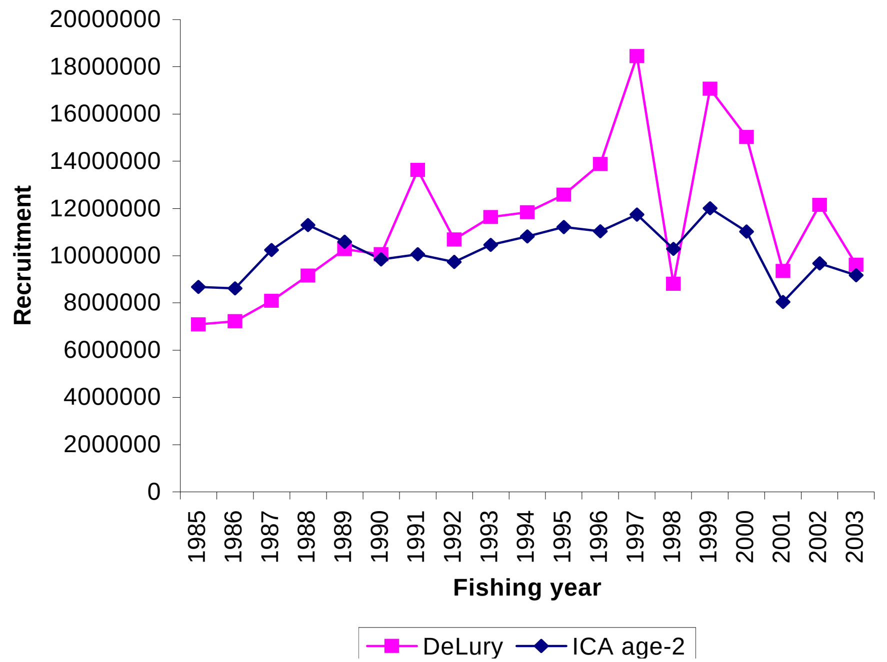
Assessment models – age structured ICA

DeLury fishing mortality rates adjusted for selectivity and those from ICA

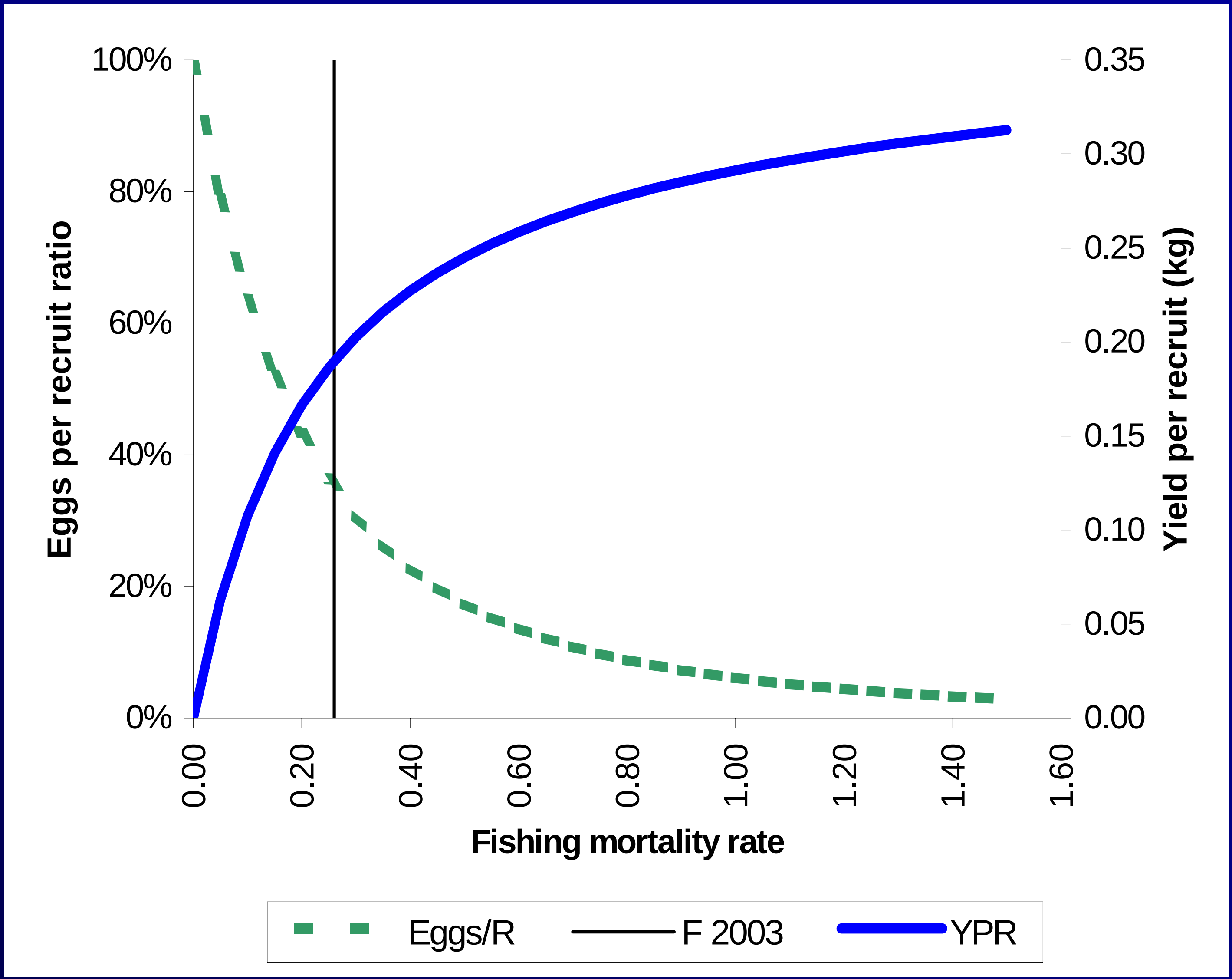


Comparison of DeLury and ICA models

Recruitment from DeLury and from ICA



Assessment models – age structured ICA



Static SPR based on eggs per recruit and yield per recruit

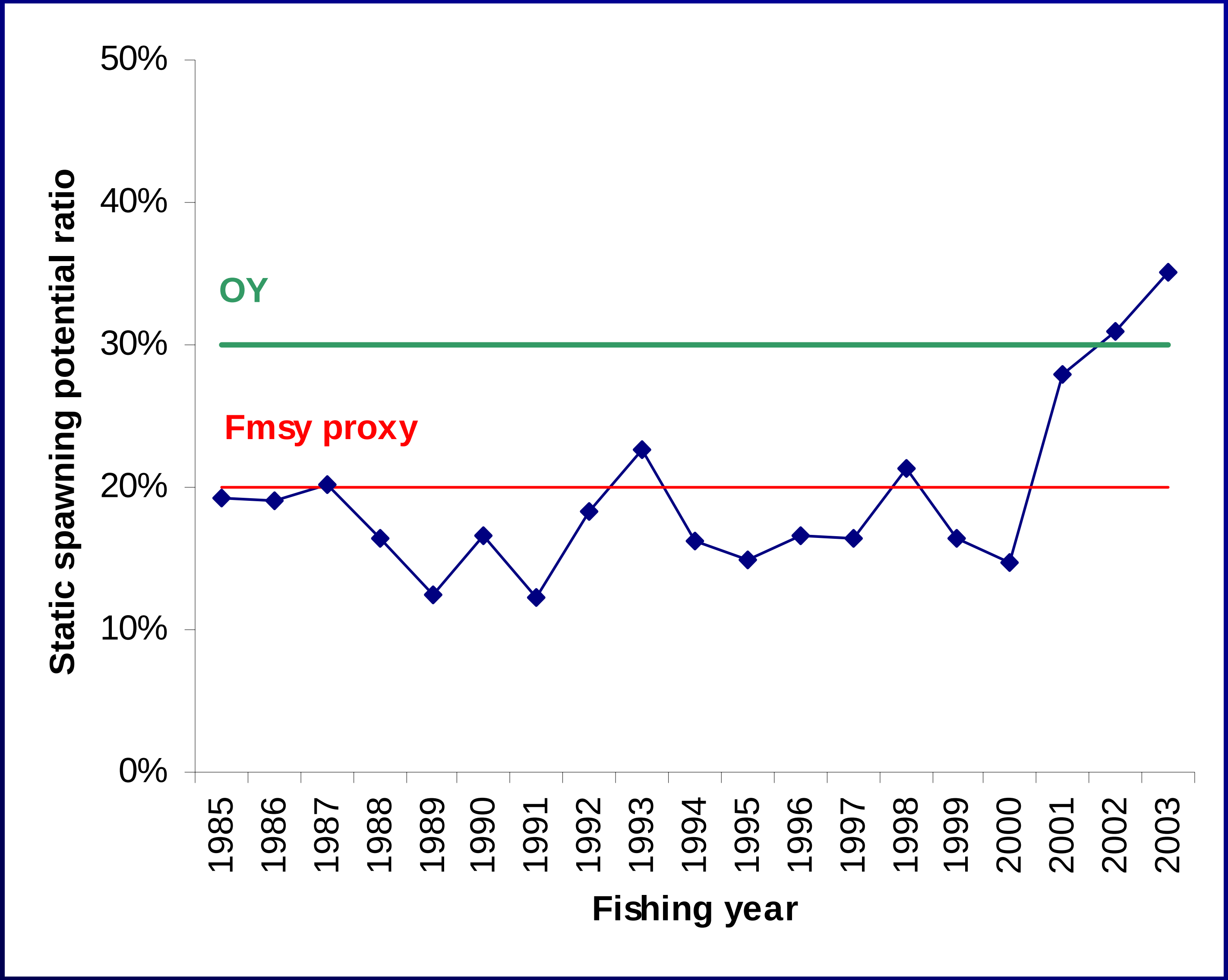
Biological Reference Points SFA Parameters

"Overfishing for species in the Spiny Lobster FMP can only be defined in terms of the fishing mortality component given the data-poor status of these species, Based on the written guidance from NMFS, the Council is setting the overfishing level as a fishing mortality rate (F) in excess of the fishing mortality rate at 20% Static SPR (F20% Static SPR).

Optimum yield (OY) for the spiny lobster fishery is the amount of harvest that can be taken by U. S. fishermen while maintaining the Spawning Potential Ratio at or above 30% Static SPR."

Amendment 6 to Spiny Lobster Fishery Management Plan (SAFMC 1998).

Biological Reference Points   SFA Parameters



Static SPR by fishing year and the management objectives of Fmsy proxy (F20%) and optimum yield (F30%)

Stock Status

Overfishing

Run	F20%	F2003	F2003/F20%	Status
Tagging	0.49	0.26	0.53	No
Lipo-Keys	0.51	0.40	0.77	No
Lipo-Tortugas	0.60	0.68	1.13	Yes
M = 0.25	0.42	0.33	0.76	No
M = 0.40	0.54	0.21	0.39	No

Stock Status

Given the contribution of recruits from outside the S.E. US, the stock-recruitment relationship cannot be determined from information in this stock assessment. Without that relationship, it is not possible to estimate spawning biomass at MSY (SSBmsy) or the Minimum Stock Size Threshold (MSST). **Thus, we cannot evaluate how the S.E. US spawning biomass in 2003-04 (5719 mt) compares to those SFA benchmarks.**

Research Recommendations

Statistical designed programs for tuning indices

- Juveniles
- Legal sized

Growth of lobsters with carapace lengths greater than 100 mm.