The prevalence of abnormal fish: proposed indicator of environmental quality

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Biological performance measures fill information gaps left by chemical-oriented water quality measures

- Toxicants have interactive effects that can't be evaluated only by measuring toxicant concentrations.
- There are so many chemicals and chemical analyses are so specific and costly that they can't measure every biologically harmful material that might be present.
- Some contaminants may have detrimental biological effects at concentrations too low to be measured.

Benefits of Monitoring the Prevalence of Abnormal fish

- Biological performance measures are important to the overall success of the program.
- They provide a biological view of the effectiveness of the restoration and remediation efforts.
- A decrease in the prevalence of abnormal fish would be a sign of success meaningful to the public and decision makers.

Objectives of St. Lucie Study

- Quantify the prevalence of abnormal fish in the St. Lucie system and nearby reference sites.
- Characterize variation as a function of species, area, and time of year.
- Explore potential relationships with potential stressors.

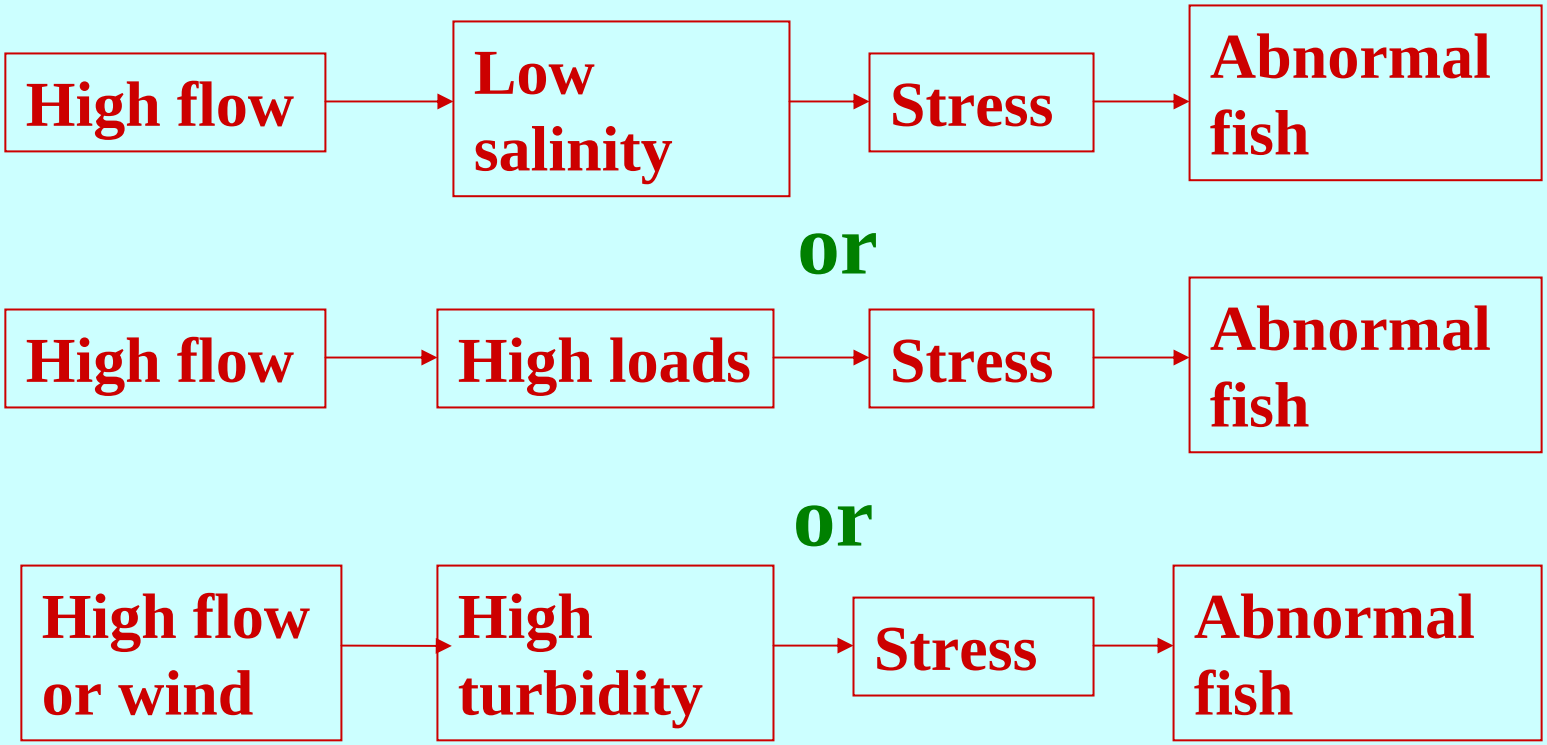
Major Stressors in St. Lucie System

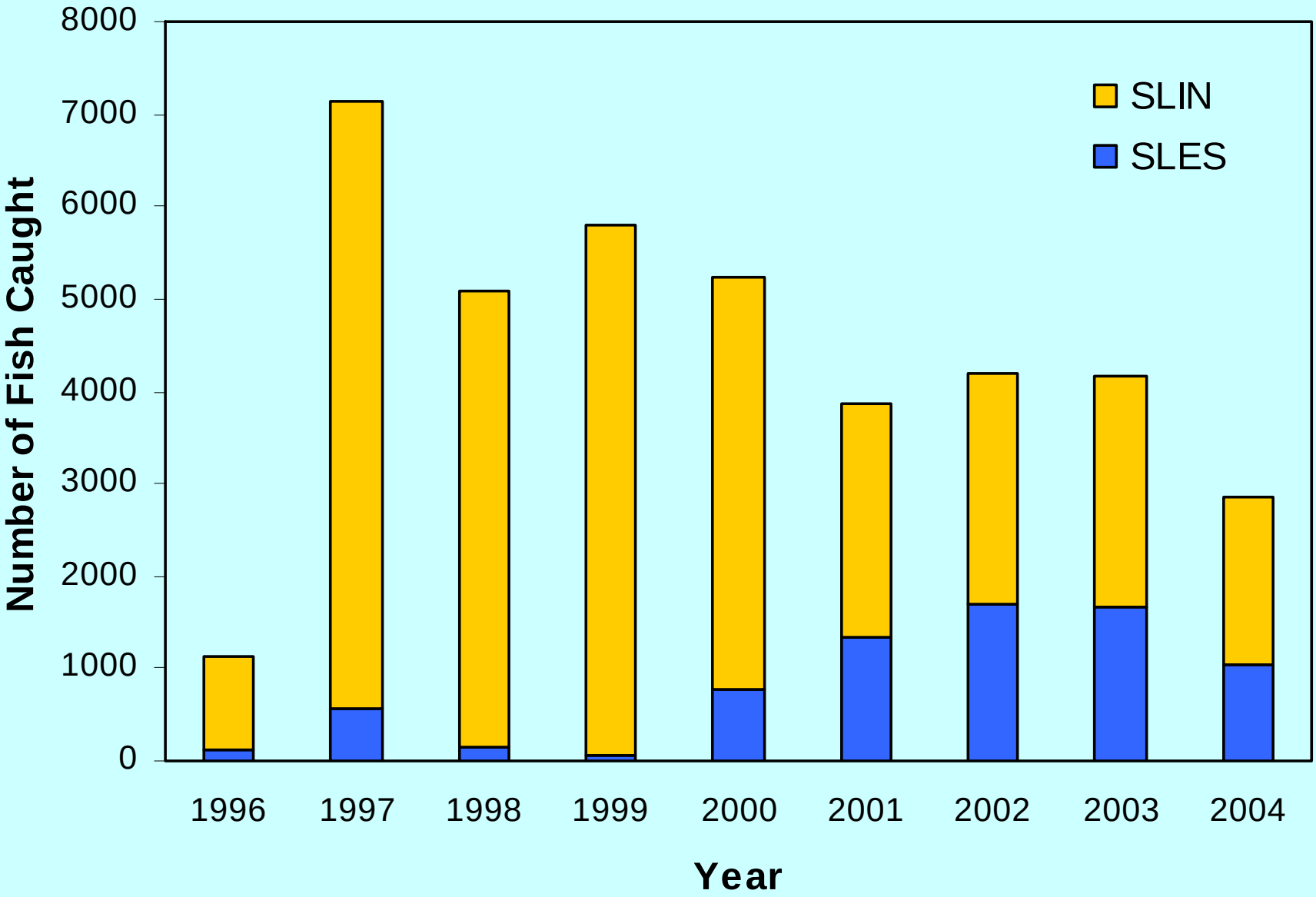
- Episotic extreme high freshwater discharges from three major canals, draining Lake Okeechobee and local agricultural areas.
- Stormwater runoff from small urban basins.
- High sediment loads from canals and unstable bottom sediments.
- Heavy metals (especially copper, but also mercury)
- Organic pesticides (including Endosulfan, DDT/DDE/DDD)

Approach

- Weekly quantitative field sampling in the St. Lucie Inlet, Estuary, and a reference site (1996-present)
- Histological description of abnormalities
- Statistical analyses
  - Generalized Linear Modeling
  - Logistic Modeling

Hypotheses


High flow
Low salinity
Stress
Abnormal fish
or
High flow
High loads
Stress
Abnormal fish
or
High flow or wind
High turbidity
Stress
Abnormal fish



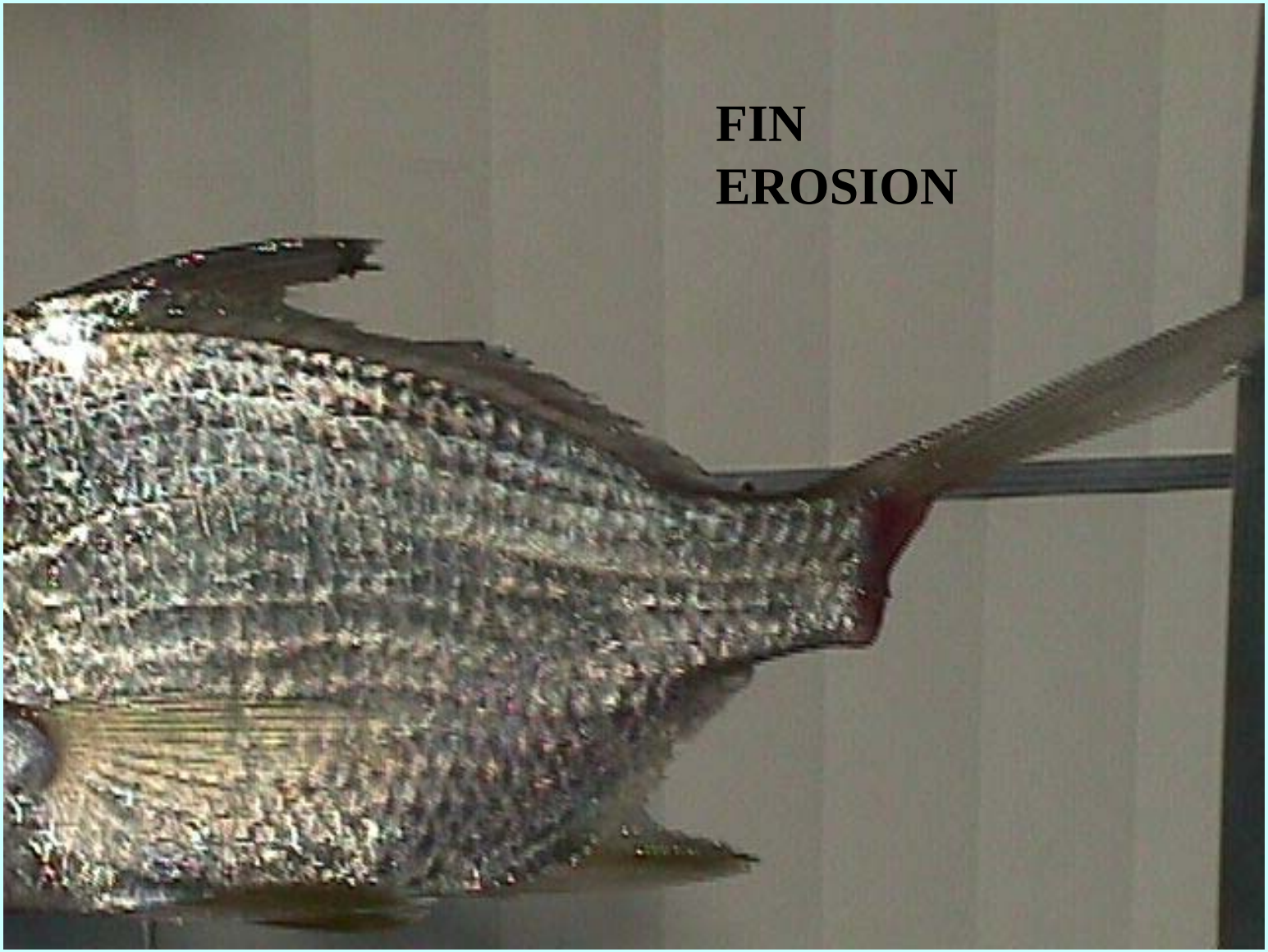
Total caught: 39,457

Major Species Caught

- Irish pompano
- Mangrove snapper
- Silver porgy
- Sand drum
- Saucereyed porgy
- White margate
- Black margate
- Lane snapper
- Blue runner
- Porkfish
- Crevalle jack
- Sheepshead
- Hardhead catfish
- Tomtate
- Pinfish
- Pigfish

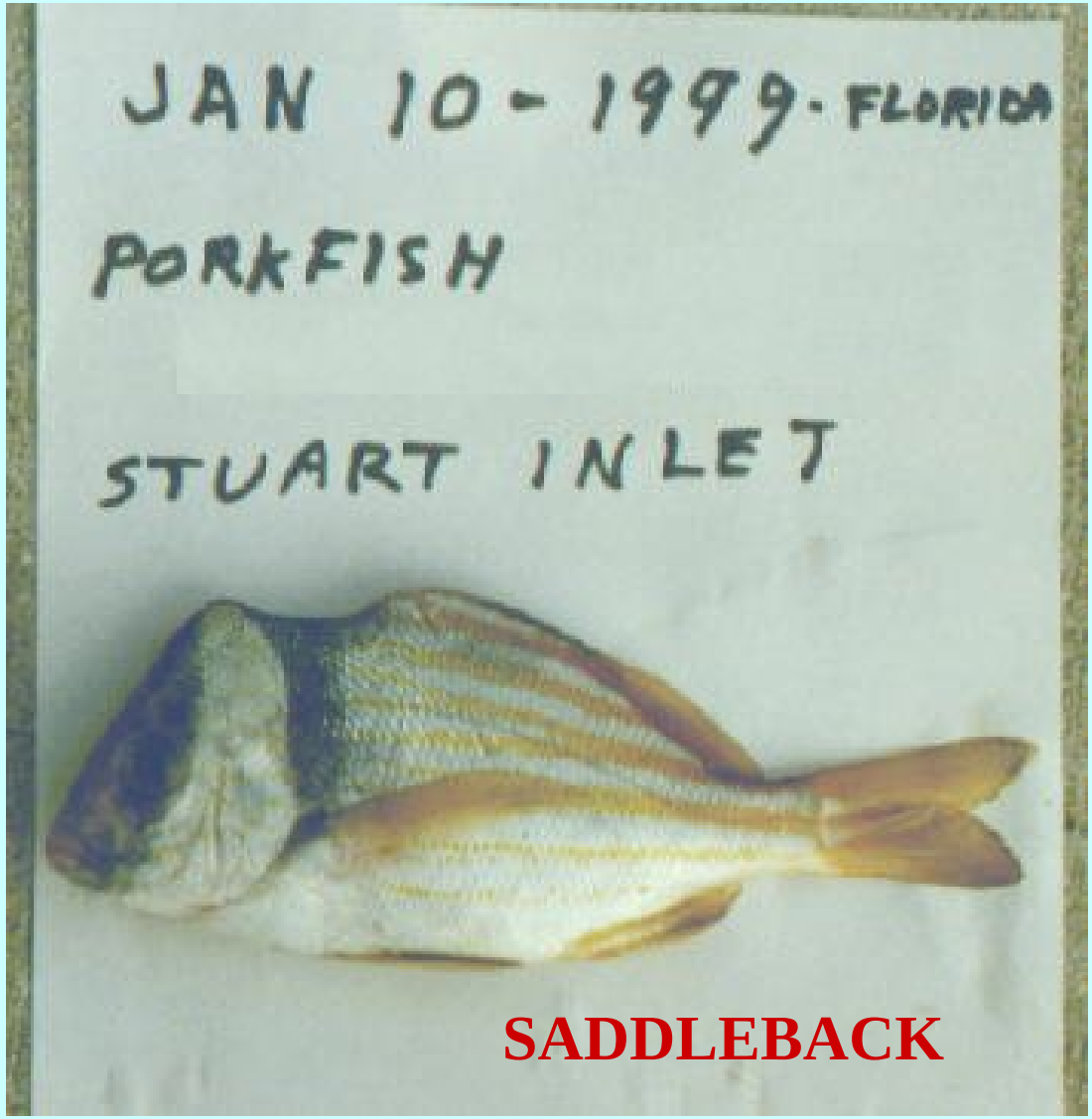
Types of abnormalities

- Fin erosion
- Red spot
- Scale disorientation
- Parasite infestation
- Skeletal or fin anomalies (deformities)
- Chromatophore clusters
- Ulcers
- Hemorrhaging


FIN
EROSION


RED SPOT

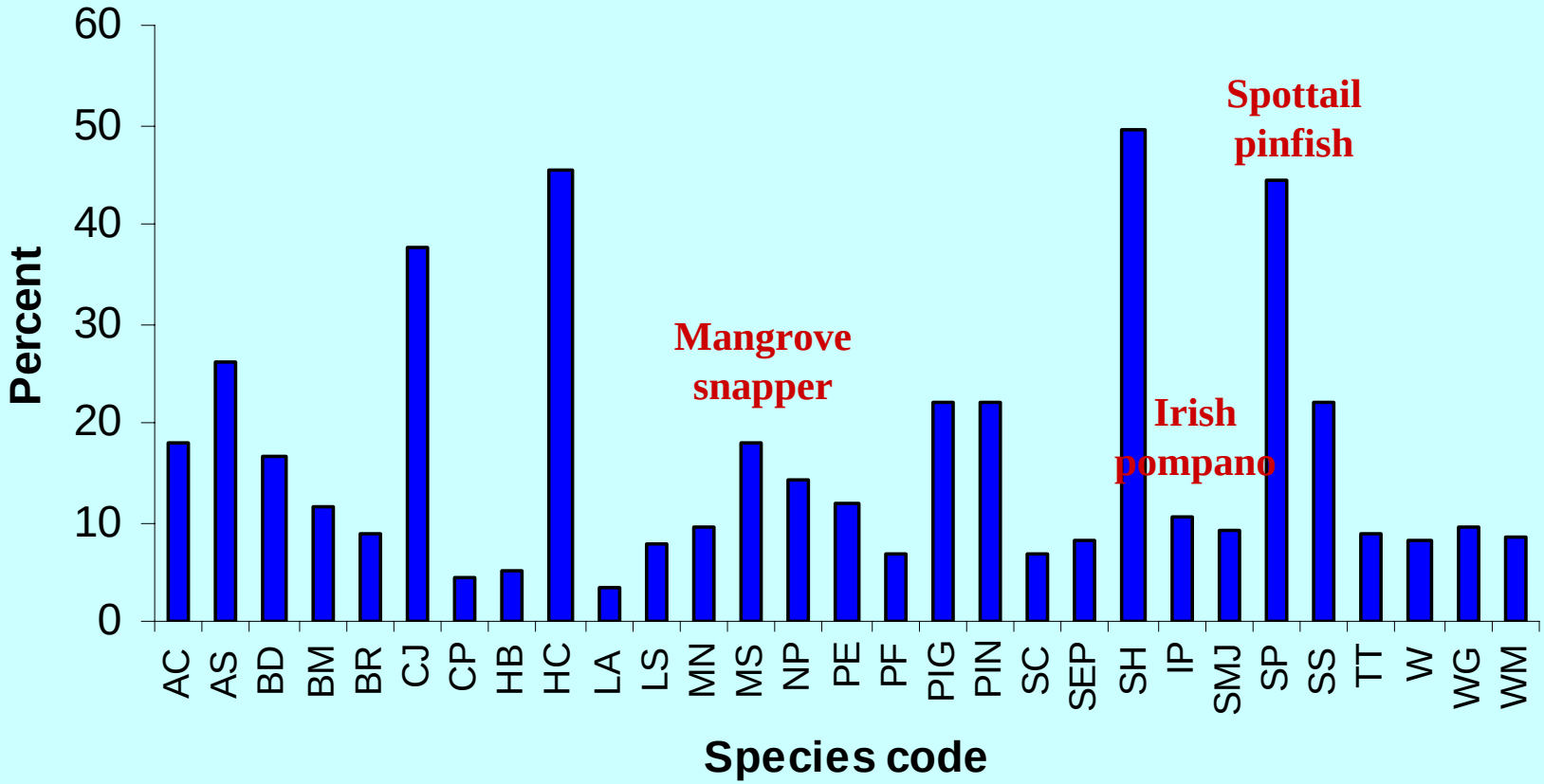

SCALE DISORIENTATION


JAN 10 - 1999 - FLORIDA
PORKFISH
STUART INLET
SADDLEBACK

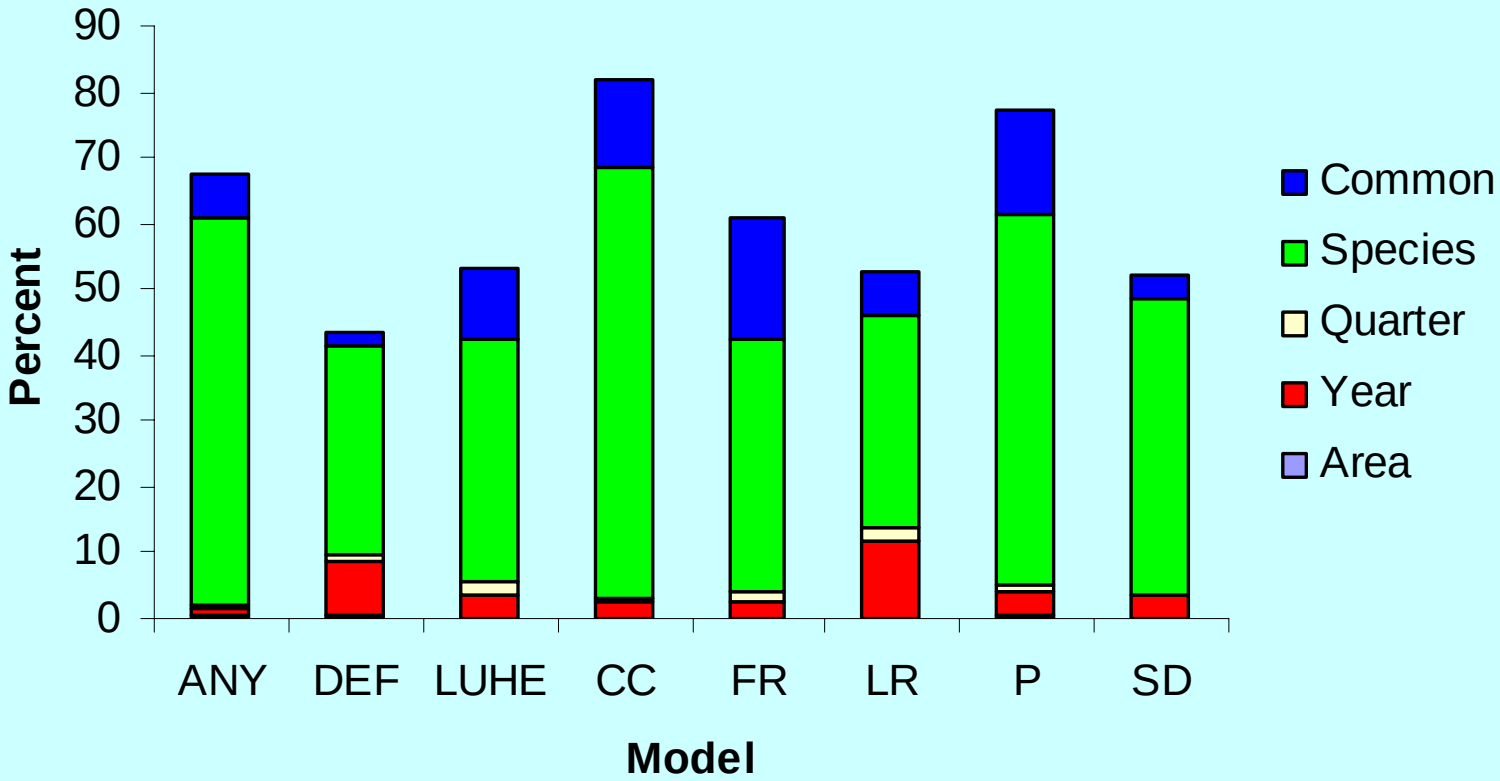
Sources of Variation Based on Generalized Linear Modeling

- Species is the most important source of variation.
- Year, Quarter, and Area become more important when the types of abnormalities are examined separately.
- Year is the most important source of variation when individual species and abnormalities are examined separately.

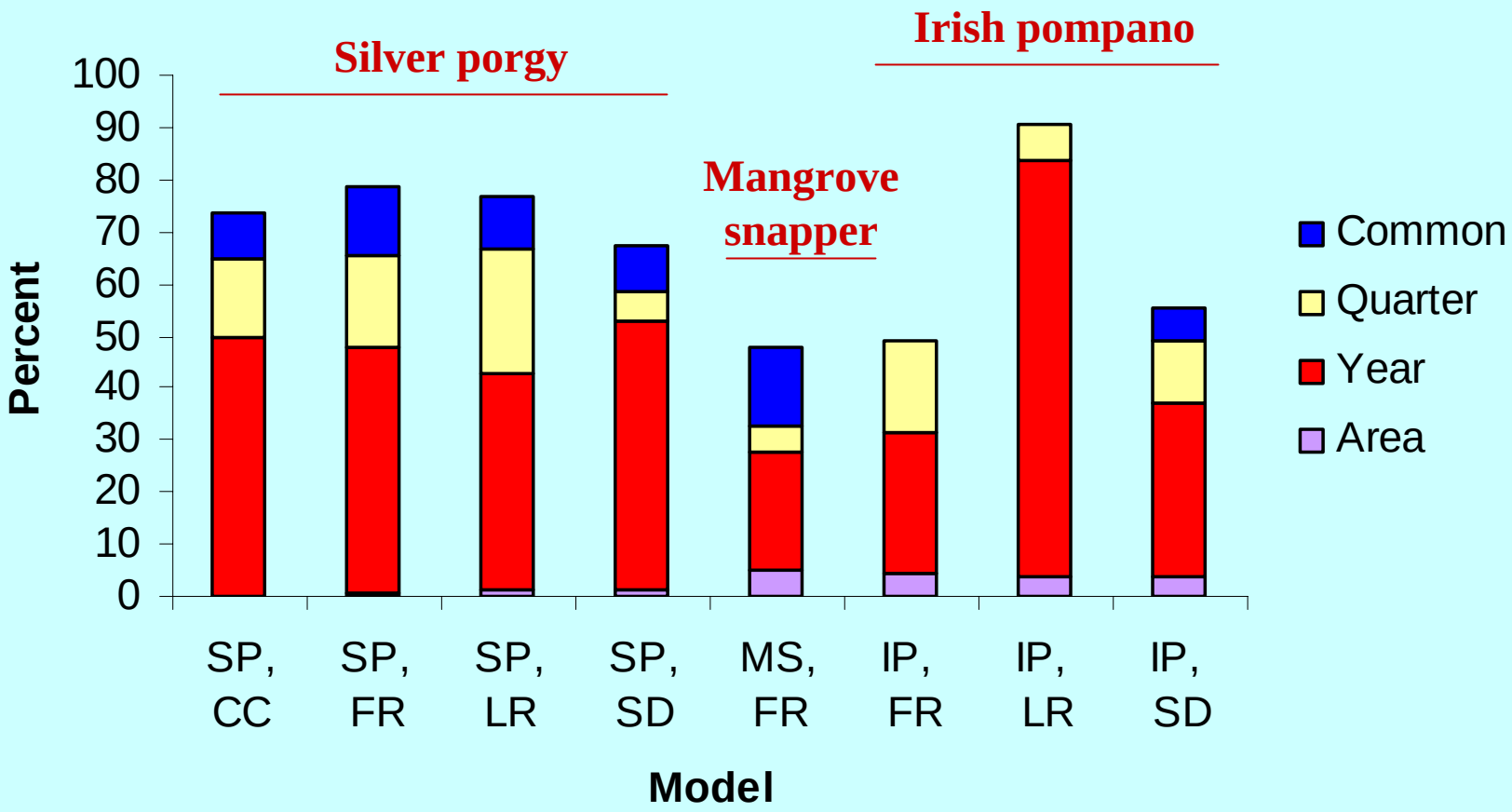
Standardized prevalence of abnormal fish, by species



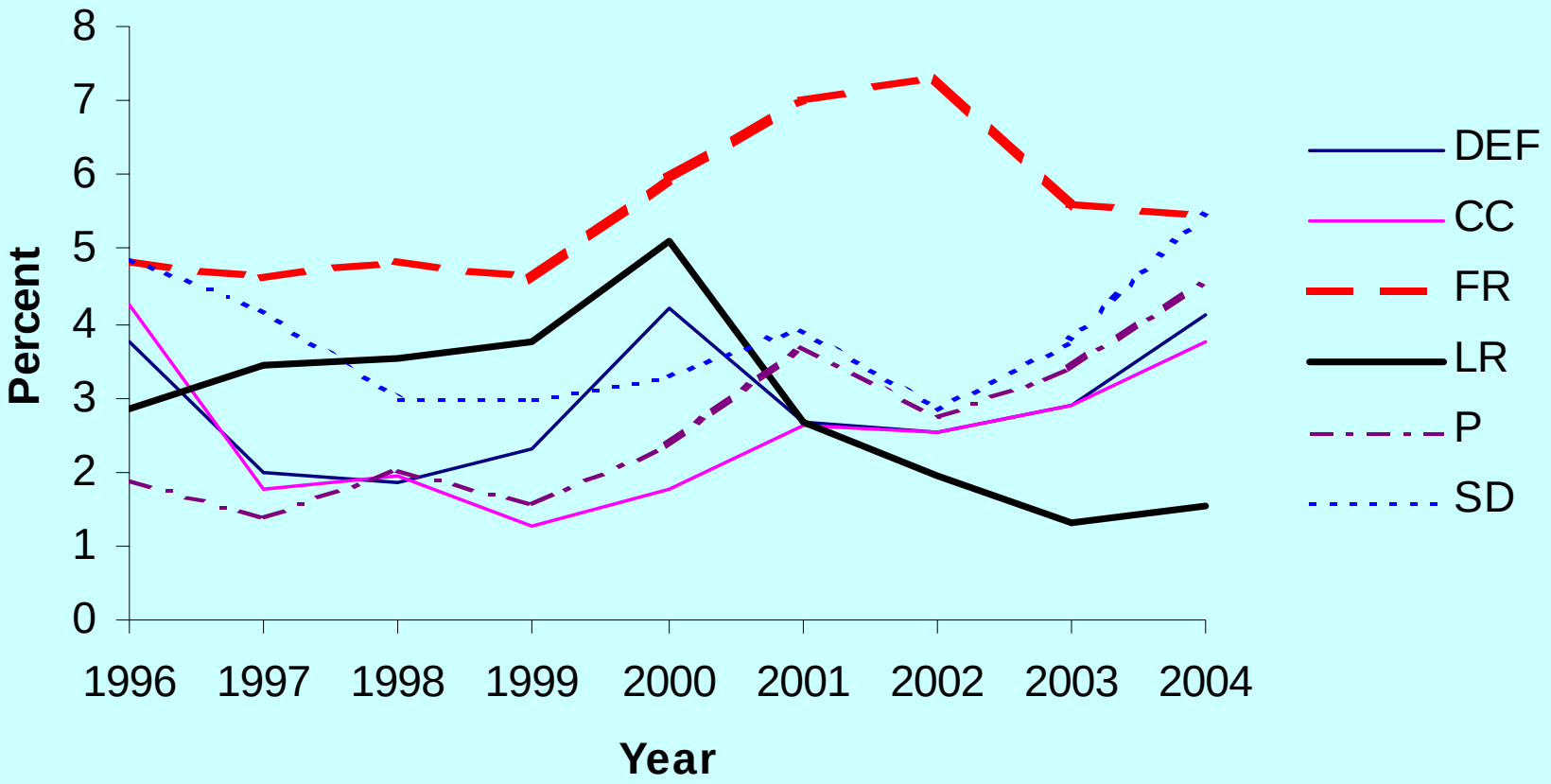
Variance explained uniquely and in common in models with all species



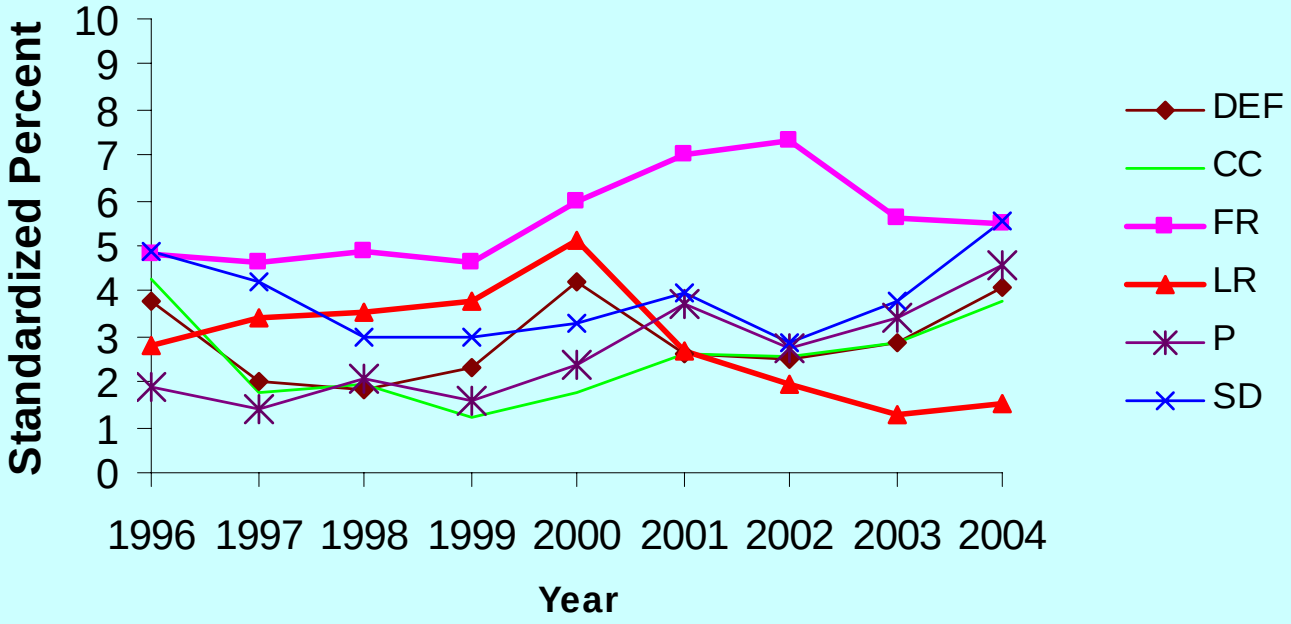
Variance in prevalence explained uniquely and in common by categorical variables in models for individual species



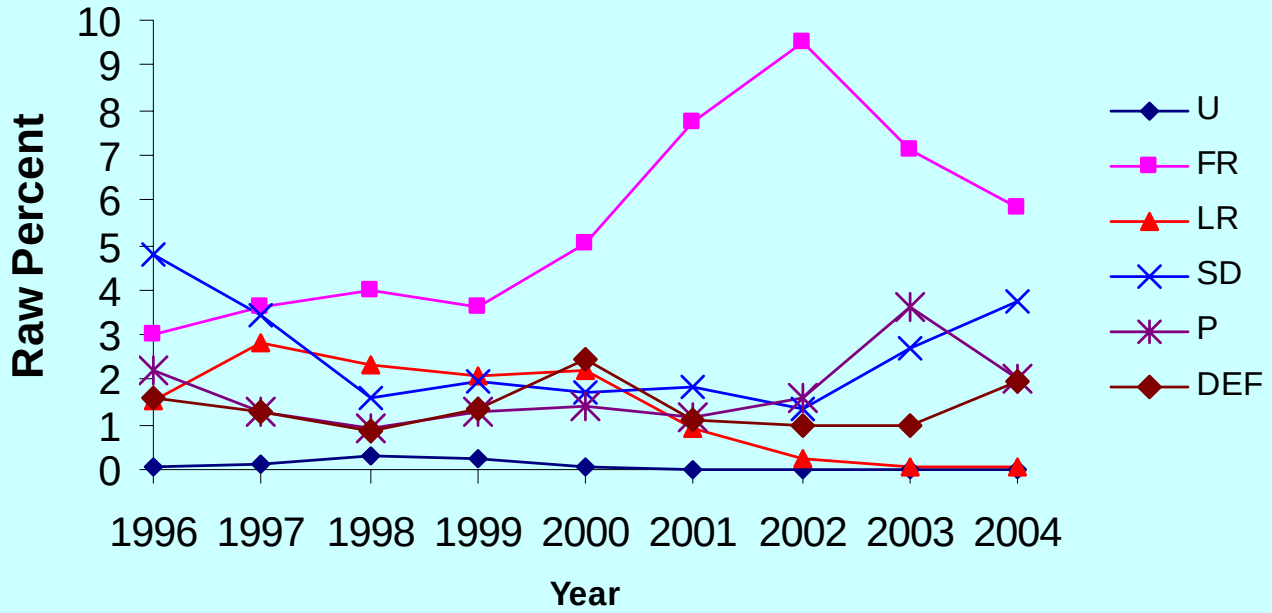
Standardized prevalence of abnormalities, by year



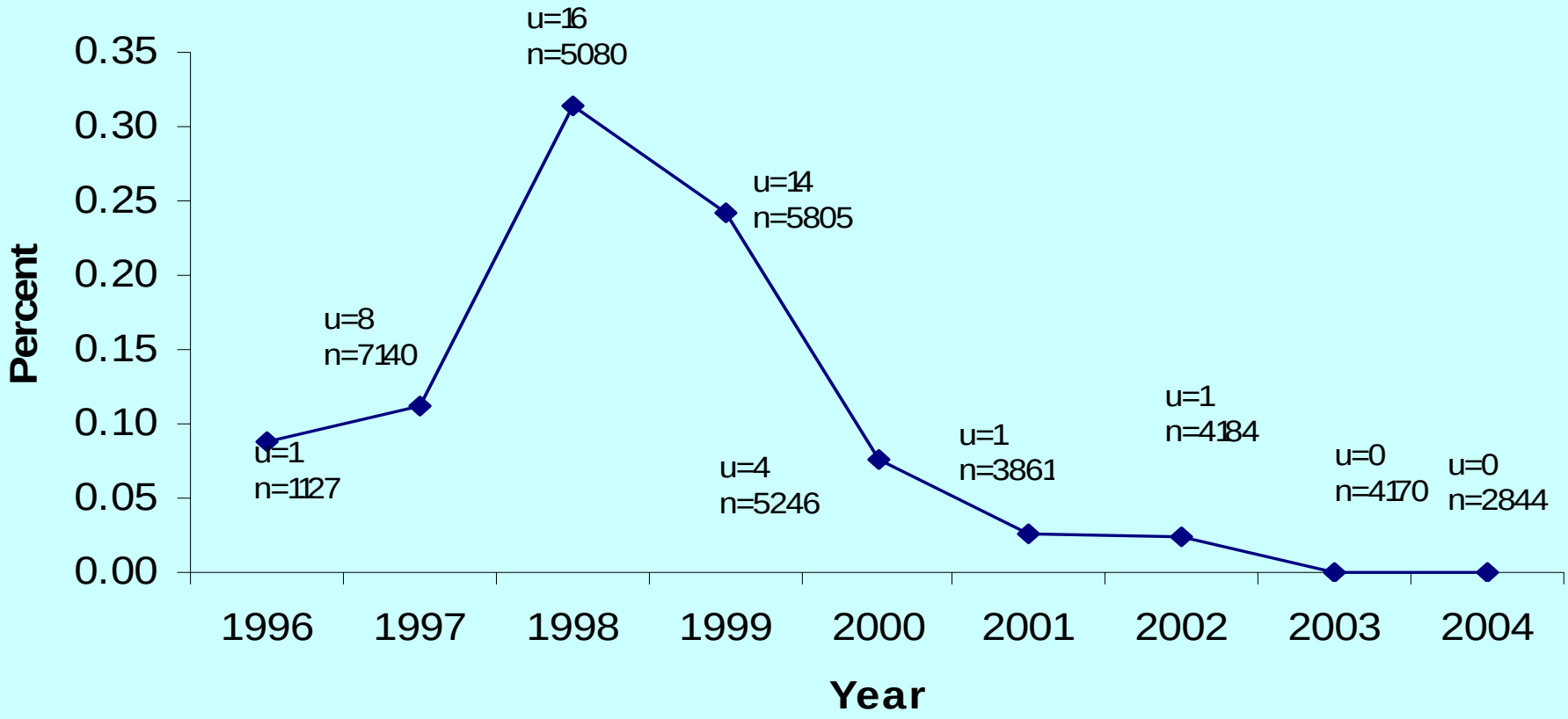
Species >100 individuals



All Fish



Raw prevalence of ulcers, by year



u=actual number of individuals with ulcers

n=actual number of individuals captured

Logistic Regression Model

- Abnormality ~

  YEAR + QUARTER + SPECIES + AREA

Logistic Regression

- Fits binomial nature of data
- Allows more flexibility in analysis
- Allows finer resolution
- Does not require transformation or addition of a value (constant or variable to eliminate zeros)

Model Improvement

REPLACE:	WITH:	SIGNIFICANCE OF CHANGE
QUARTER	MONTH	P<0.005
AREA	SITE	P<0.001

Comparison of St. Lucie area to reference areas

- Reference sites: Jupiter Inlet, Lower Loxahatchee River, Ft Pierce Inlet, IRL near Taylor Creek
- Data from July 2000 to March 2005
- Compared as 2 areas, 6 areas, or 60 sites.

St. Lucie vs. Reference

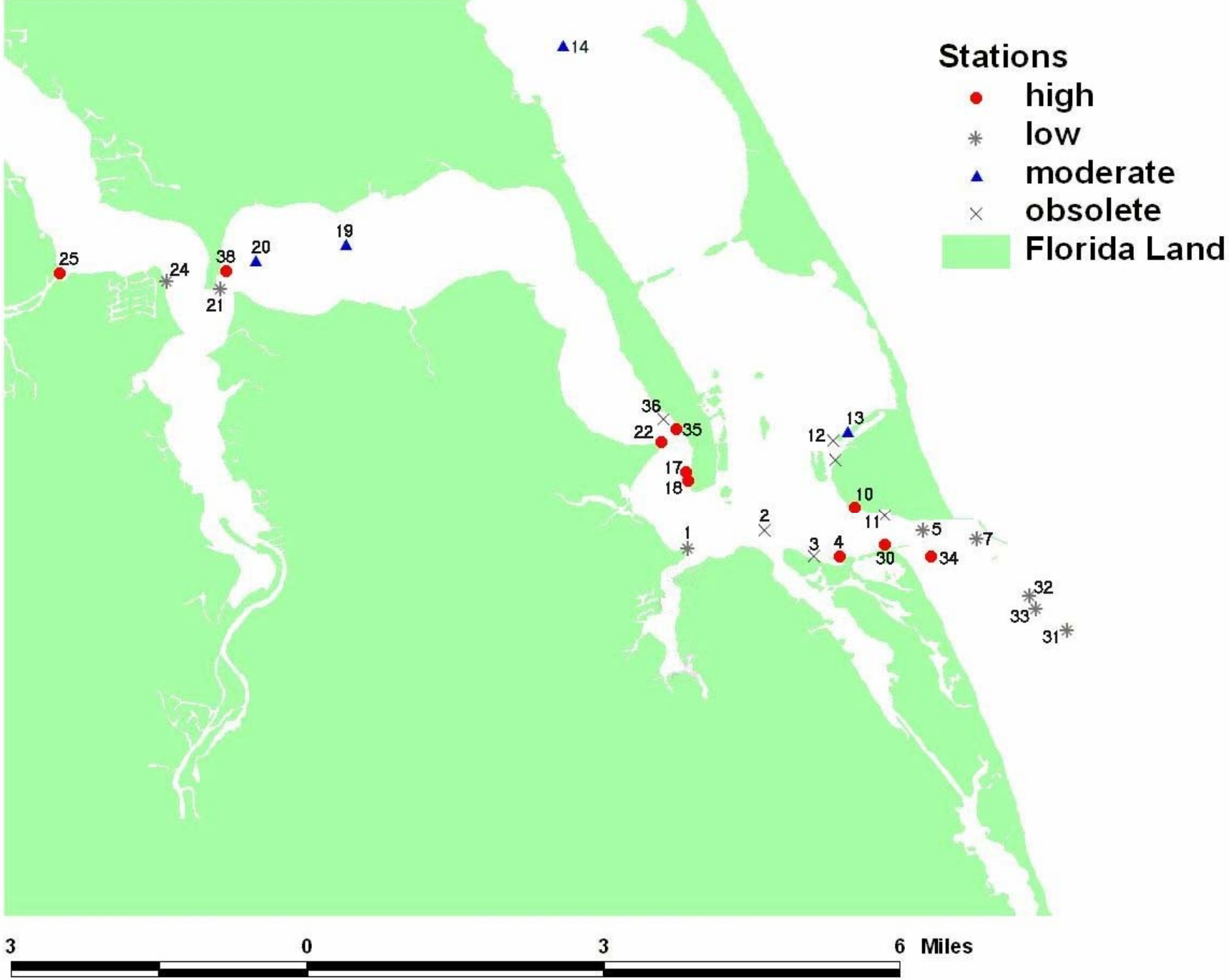
Abnormality	Significance of adding AREA	Prevalence (%), St. Lucie > Ref
ANY	$P < 0.001$	$11.02 > 7.58$
LUHE	$P < 0.001$	$4.51 > 3.70$
DEF	n.s.	

St. Lucie vs. Reference, All Species

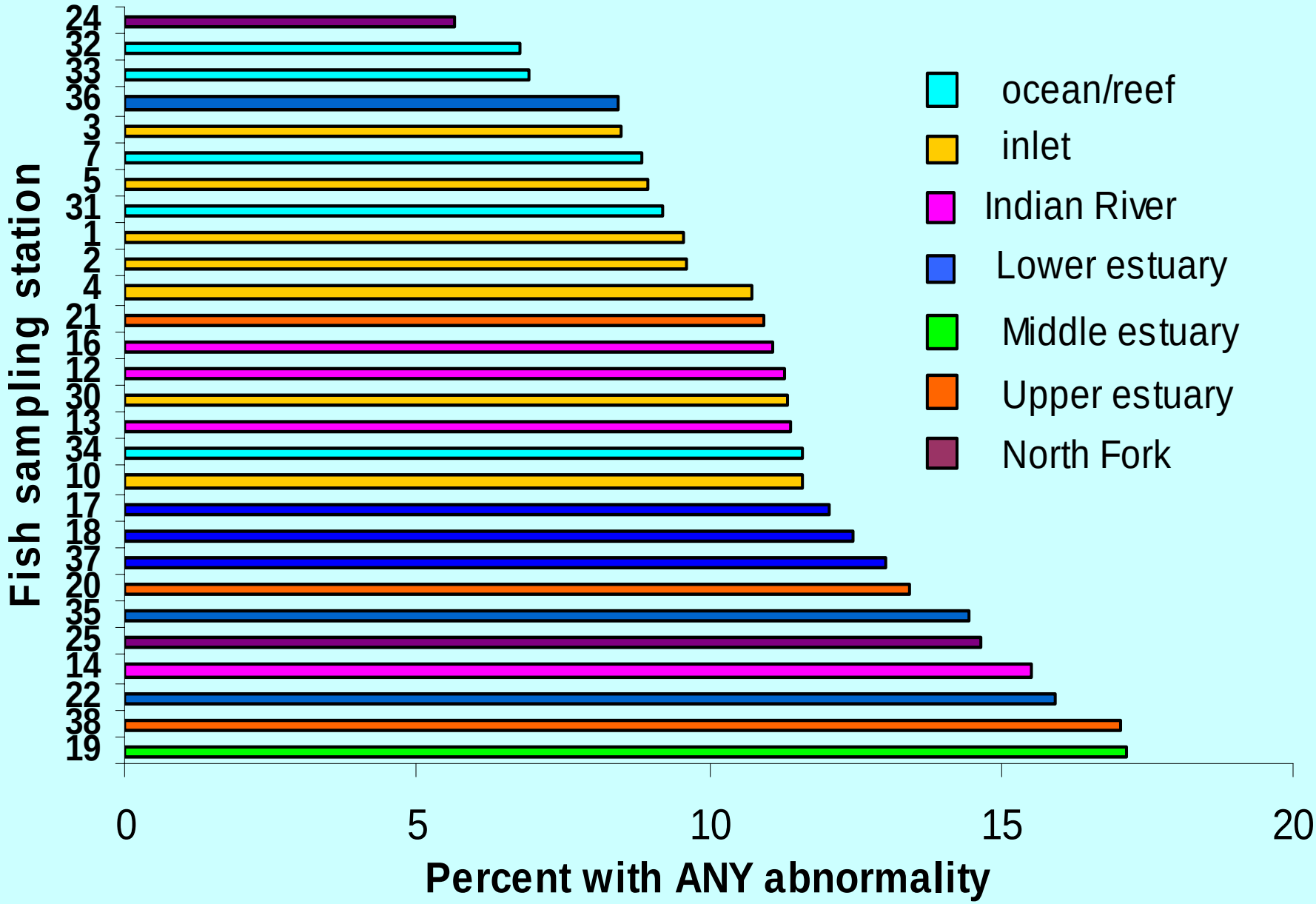
Abnormality	Significance of adding AREA	Prevalence (%) St. Lucie vs Ref
Chromatophoroma	P < 0.001	0.00062 > 0.00024
Fin erosion	P < 0.001	3.85 > 3.08
Red spot	n.s.	
Parasite infestation	P < 0.001	0.0013 > 0.00045
Scale disorientation	n.s.	

St. Lucie vs. Reference, Silver Porgy

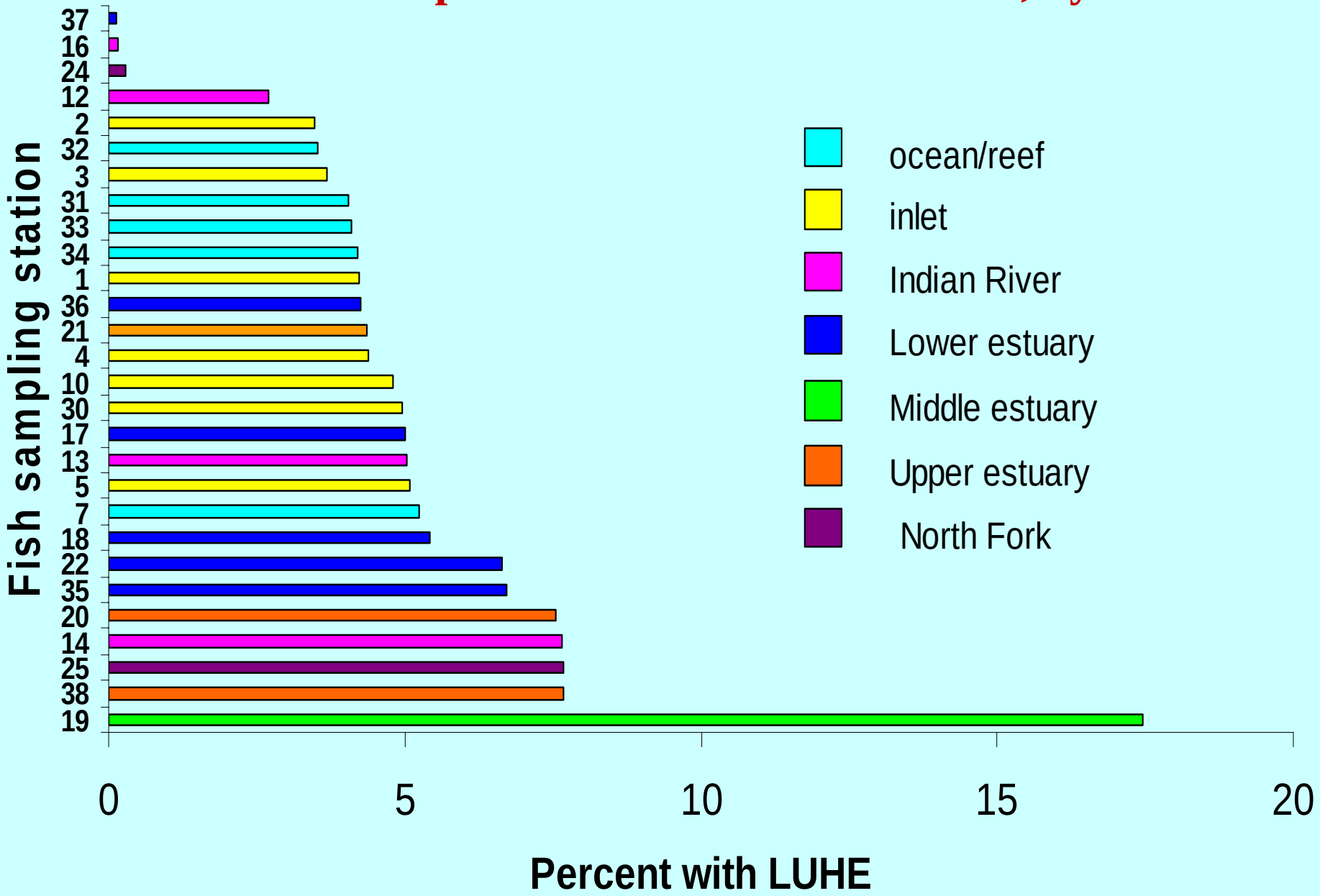
Abnormality	Significance of adding AREA	Prevalence (%) St. Lucie vs Ref.
Chromatophoroma	$P < 0.001$	$34.68 > 16.55$


Stations
high
low
moderate
obsolete
Florida Land
14
19
25
24
38
20
21
36
22
35
17
18
13
12
10
11
2
1
3
4
30
5
34
7
32
33
31
3
0
3
6
Miles

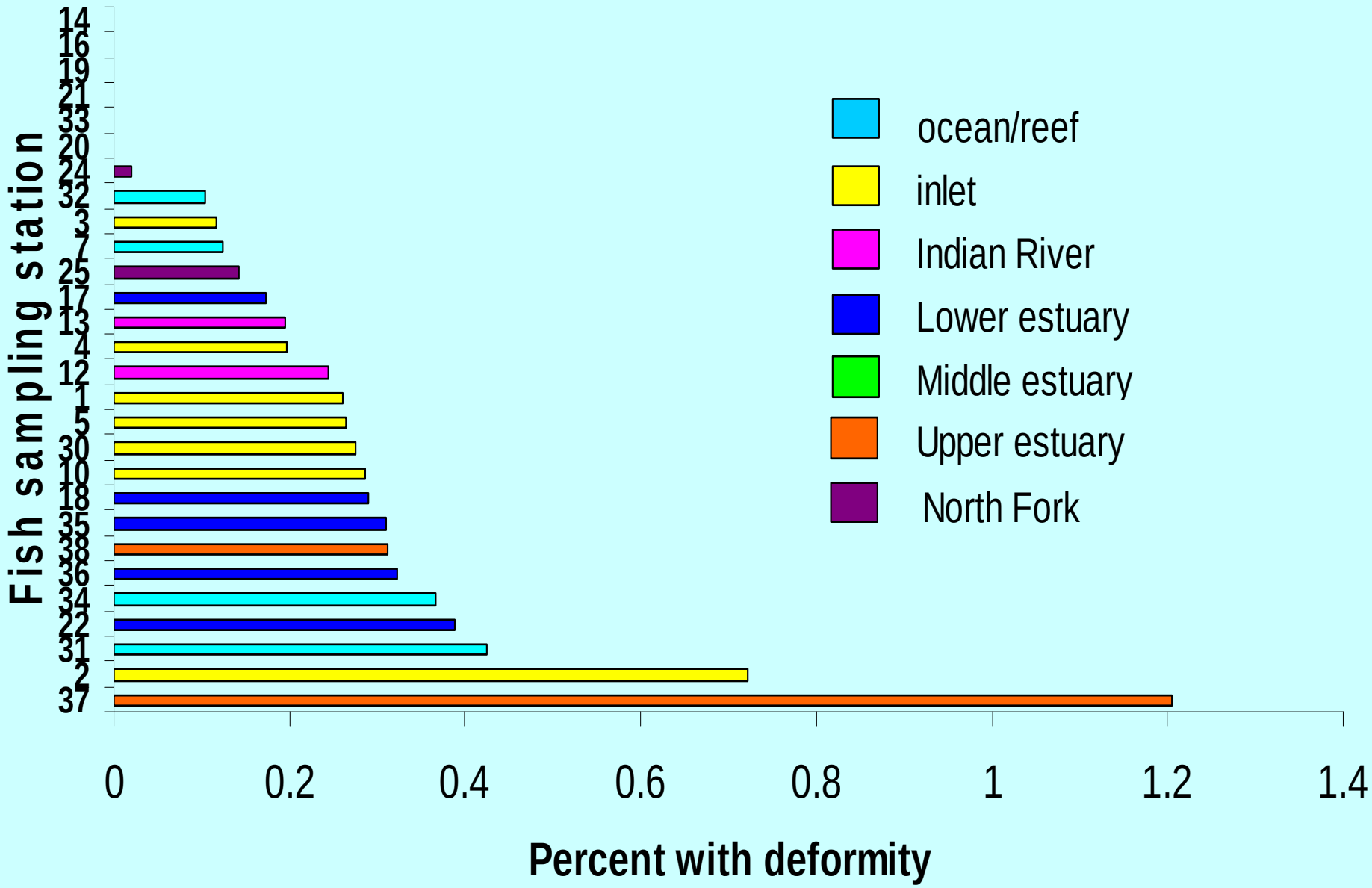
Standardized prevalence of abnormal fish, by site

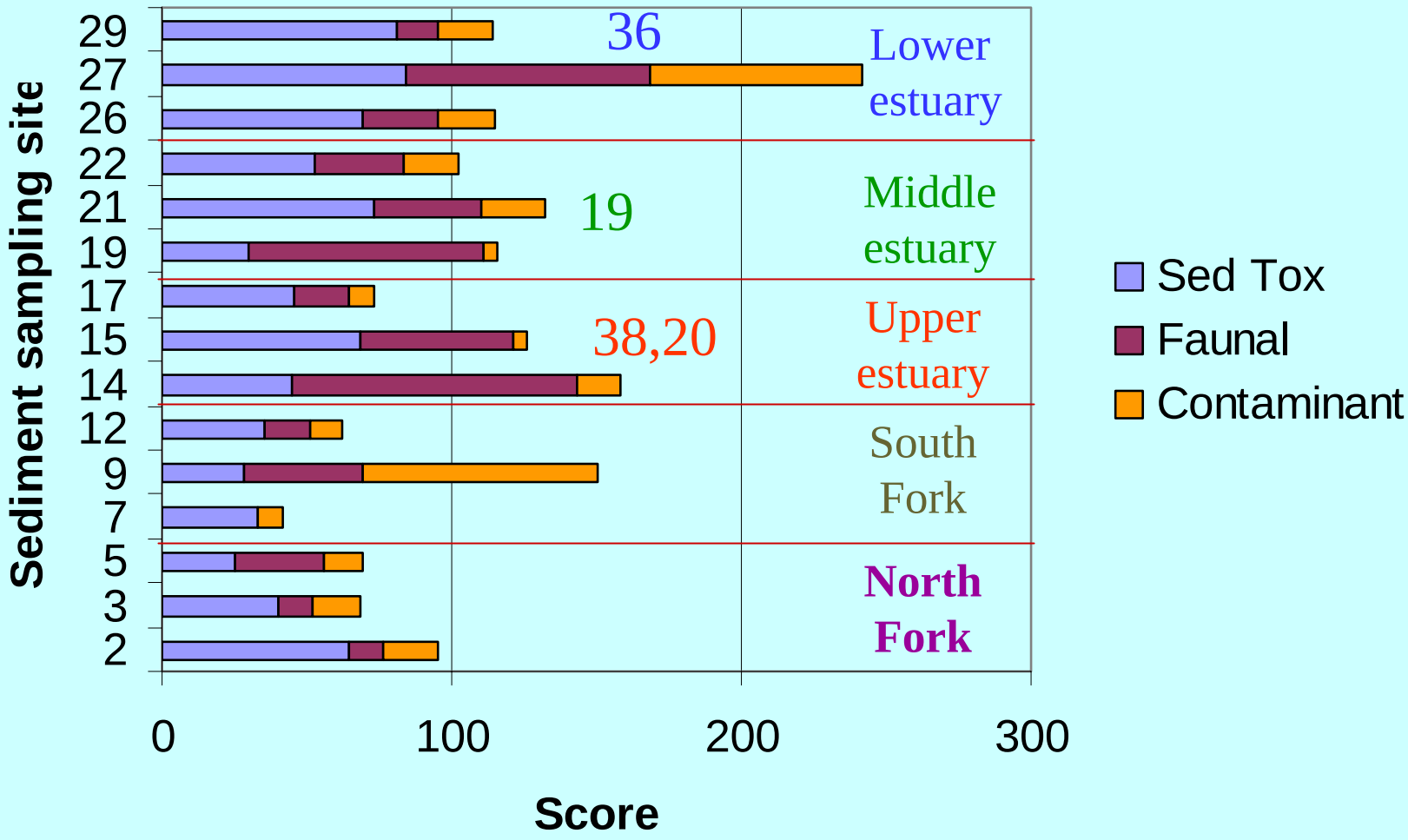


Standardized prevalence of fish with LUHE, by site



Standardized prevalence of fish with deformity, by site





From NOS summary, by stratum

Freshwater discharges

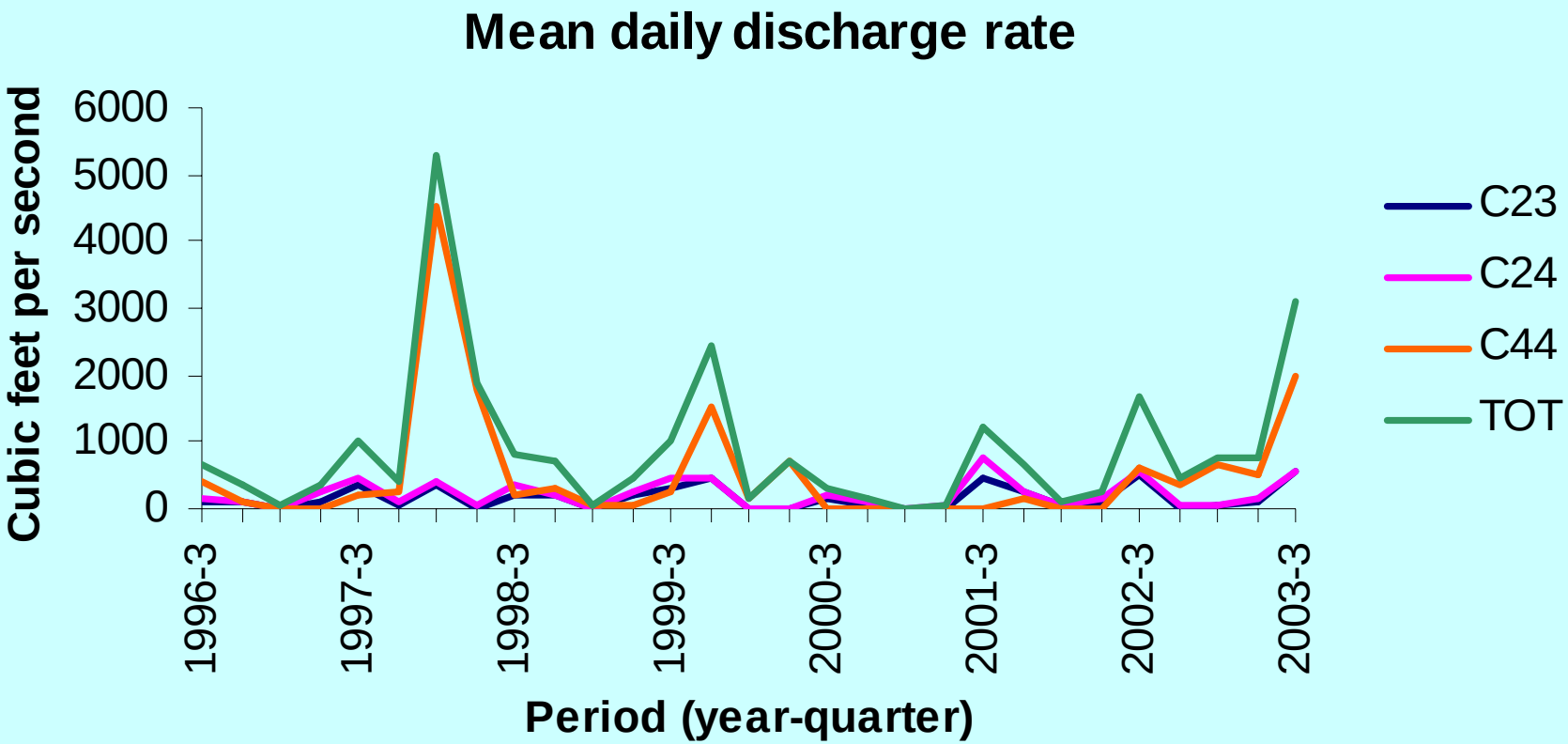
Water control structure	Canal
S48	C23
S49	C24
S80	C44 (from Lake Okeechobee)

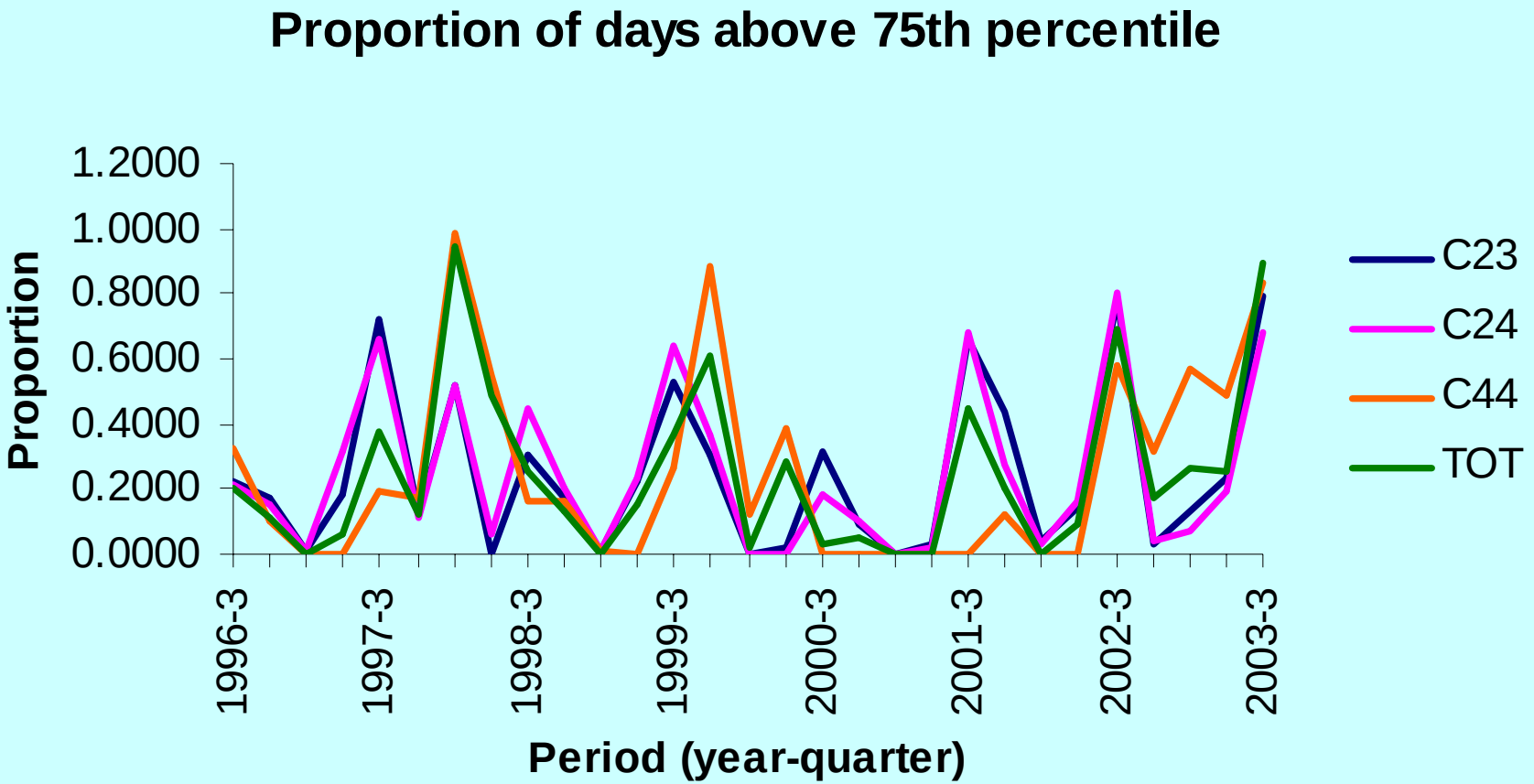
Models

ANY~Species+Area+C23+C24+C44

ANY~Species+Area+(C23+C24+C44)

- C23, C24, and C44: separate or summed
  - Mean daily discharge
  - Proportion of days flow above 75th percentile
  - Proportion of days flow above 2000 cfs
- Lags: current month (CM), 1-month (M), 2-month (MM), and 3-month-lagged (MMM)


Mean daily discharge rate
Cubic feet per second
6000
5000
4000
3000
2000
1000
0
1996-3
1997-3
1998-3
1999-3
2000-3
2001-3
2002-3
2003-3
Period (year-quarter)
C23
C24
C44
TOT


Proportion of days above 75th percentile
Proportion
1.2000
1.0000
0.8000
0.6000
0.4000
0.2000
0.0000
1996-3
1997-3
1998-3
1999-3
2000-3
2001-3
2002-3
2003-3
Period (year-quarter)
C23
C24
C44
TOT

Relationships with discharge

- Abnormalities are more significantly related to individual discharges than to combined discharges. Mean and days above 75th percentile seem equally meaningful.
- All lags are significant for ANY abnormality.
- Only a few of the alternative models for LUHE and DEF are significant.

SUMMARY

- SPECIES is biggest factor explaining variation
- Individual abnormalities show greater variation among years
- Abnormality prevalence is significantly greater in the St. Lucie than the reference areas
- Visual patterns of standardized abnormalities among stations suggest ANY and LUHE are greater upstream and DEF greater downstream.
- Hydrology contributes significantly to explaining variation.