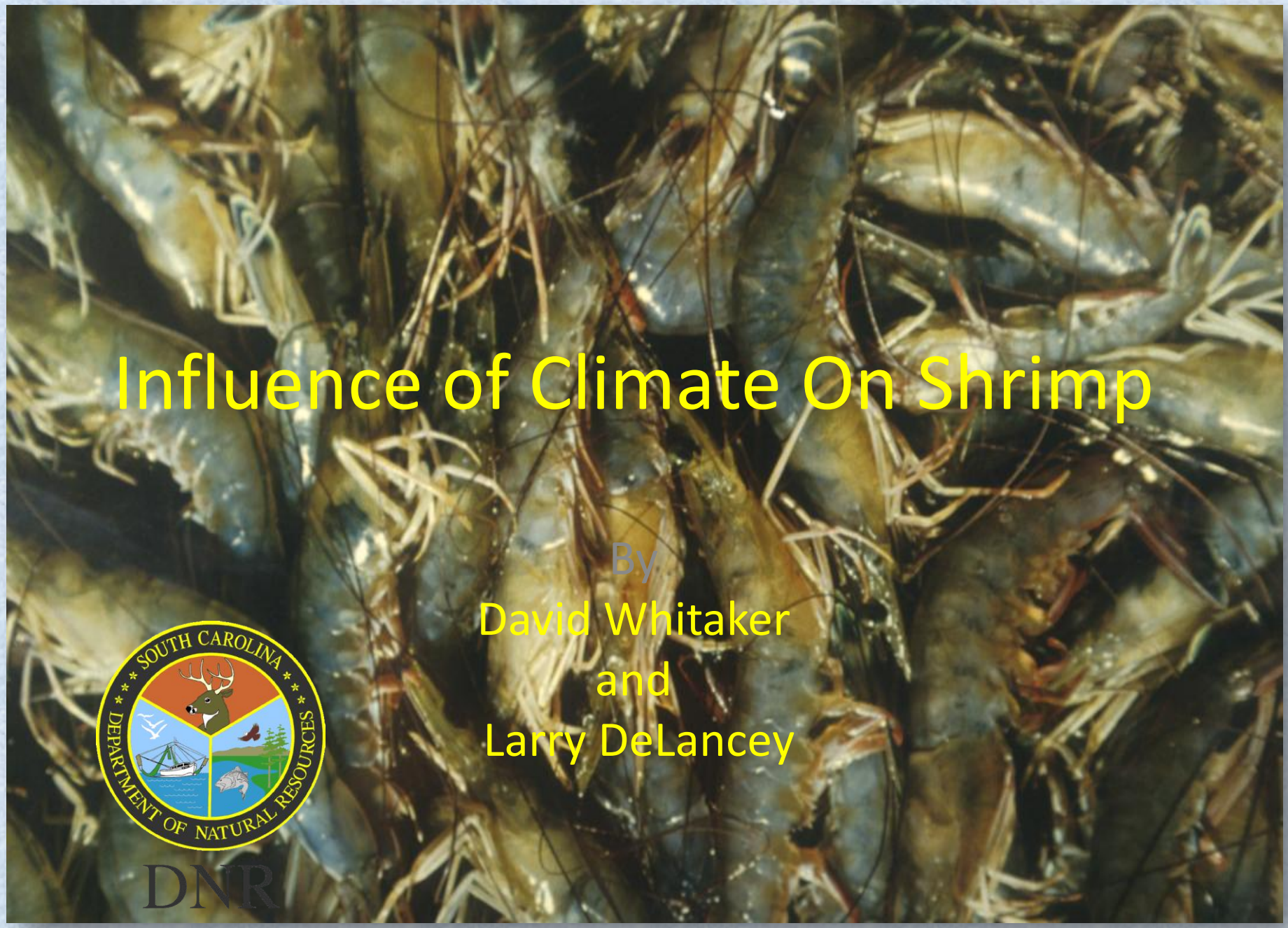
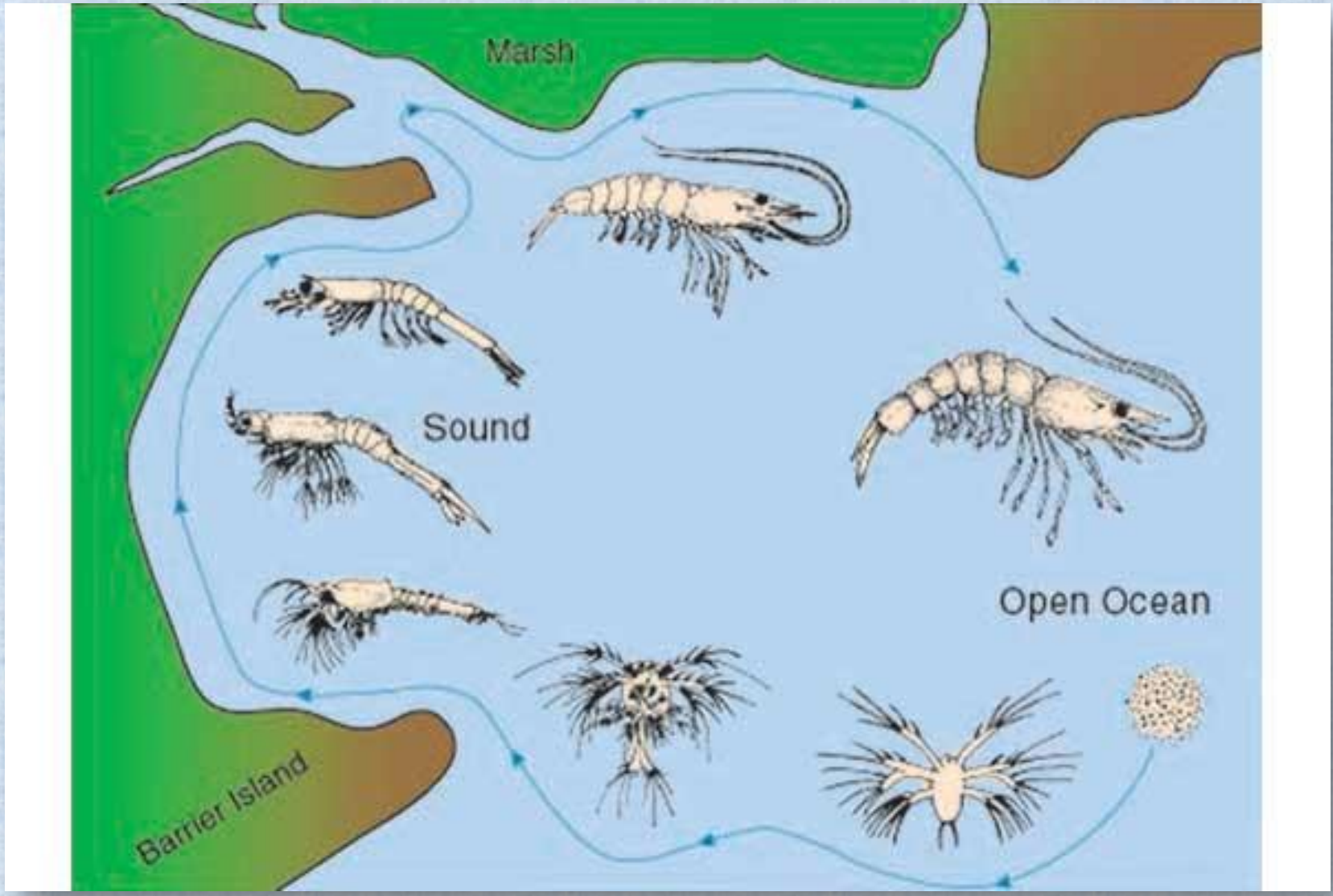

Influence of Climate On Shrimp
By
David Whitaker
and
Larry DeLancey
SOUTH CAROLINA
DEPARTMENT OF NATURAL RESOURCES
DNR

Brown Shrimp

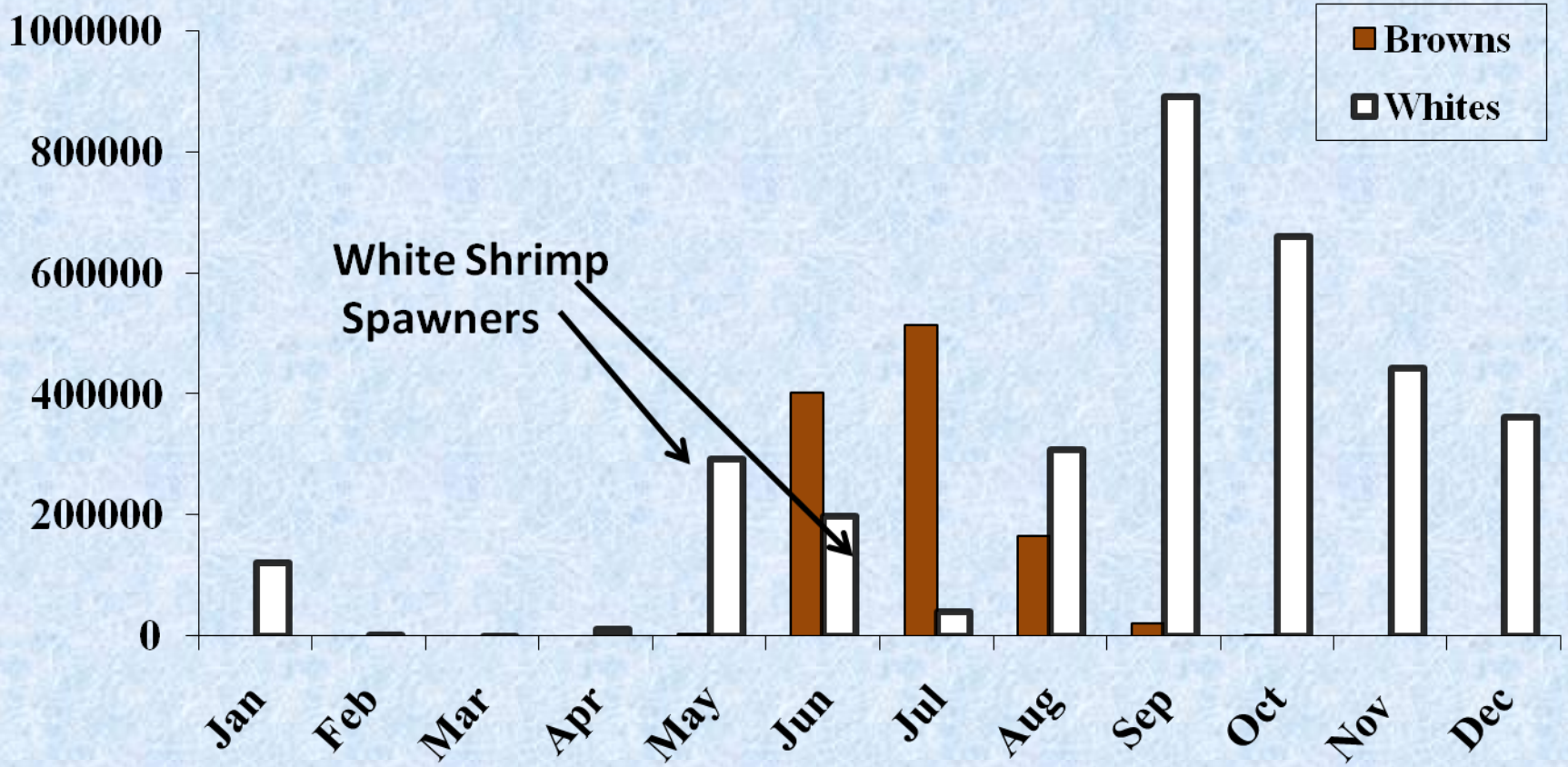
Pink Shrimp

White Shrimp



Shrimp spawn just offshore and tidal currents carry postlarvae into estuaries.

Average Monthly Commercial Landings by Species

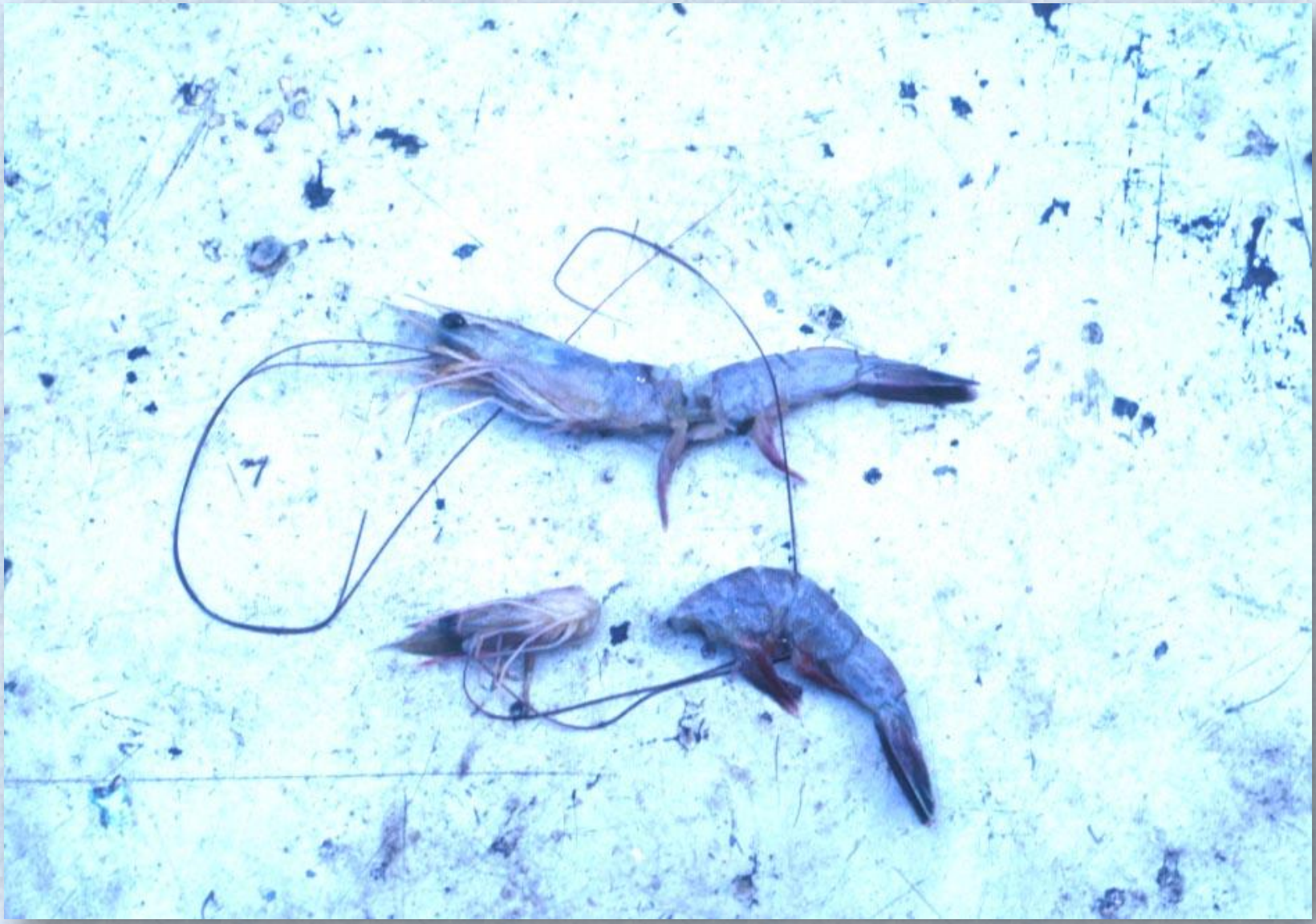


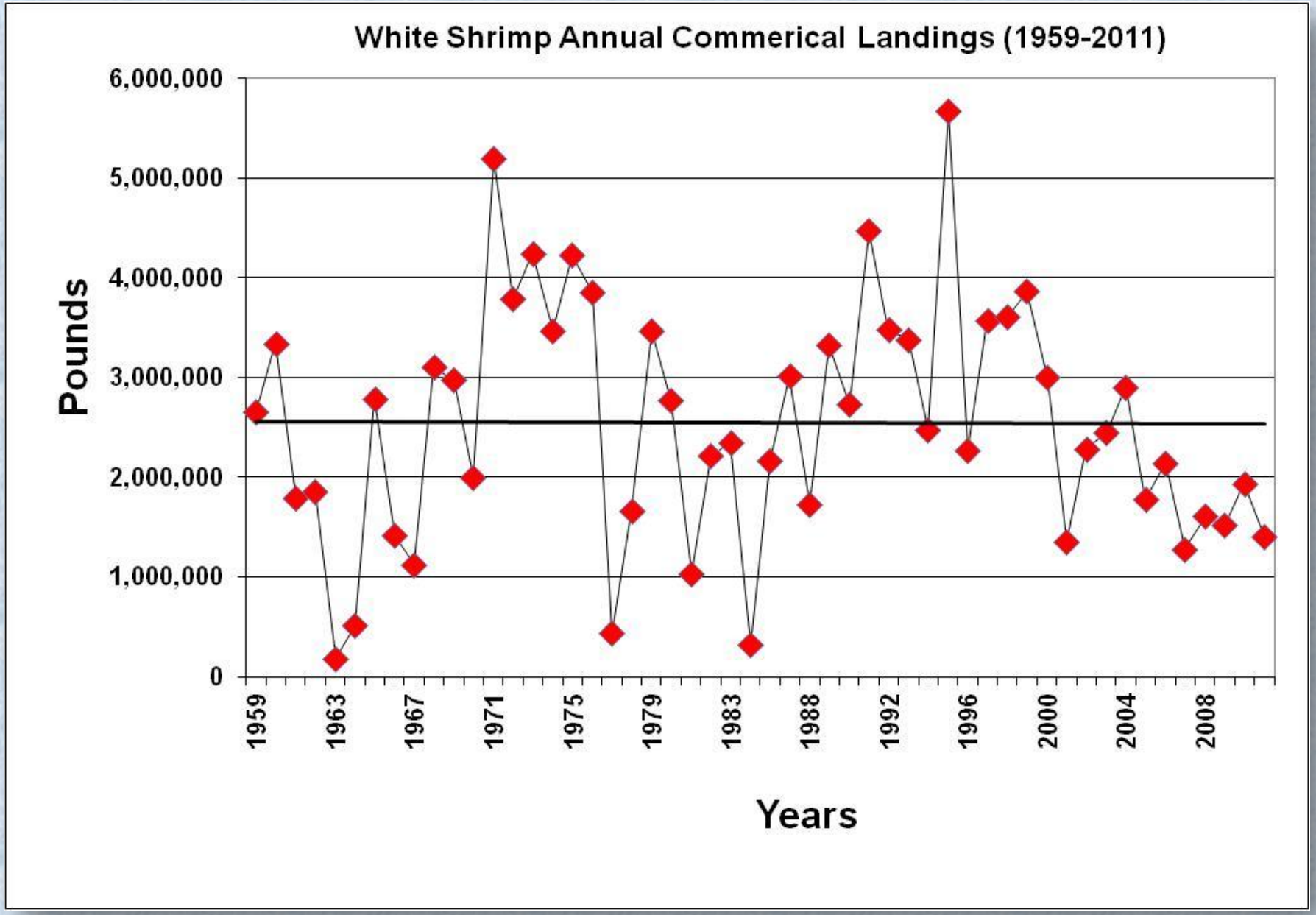
White Shrimp

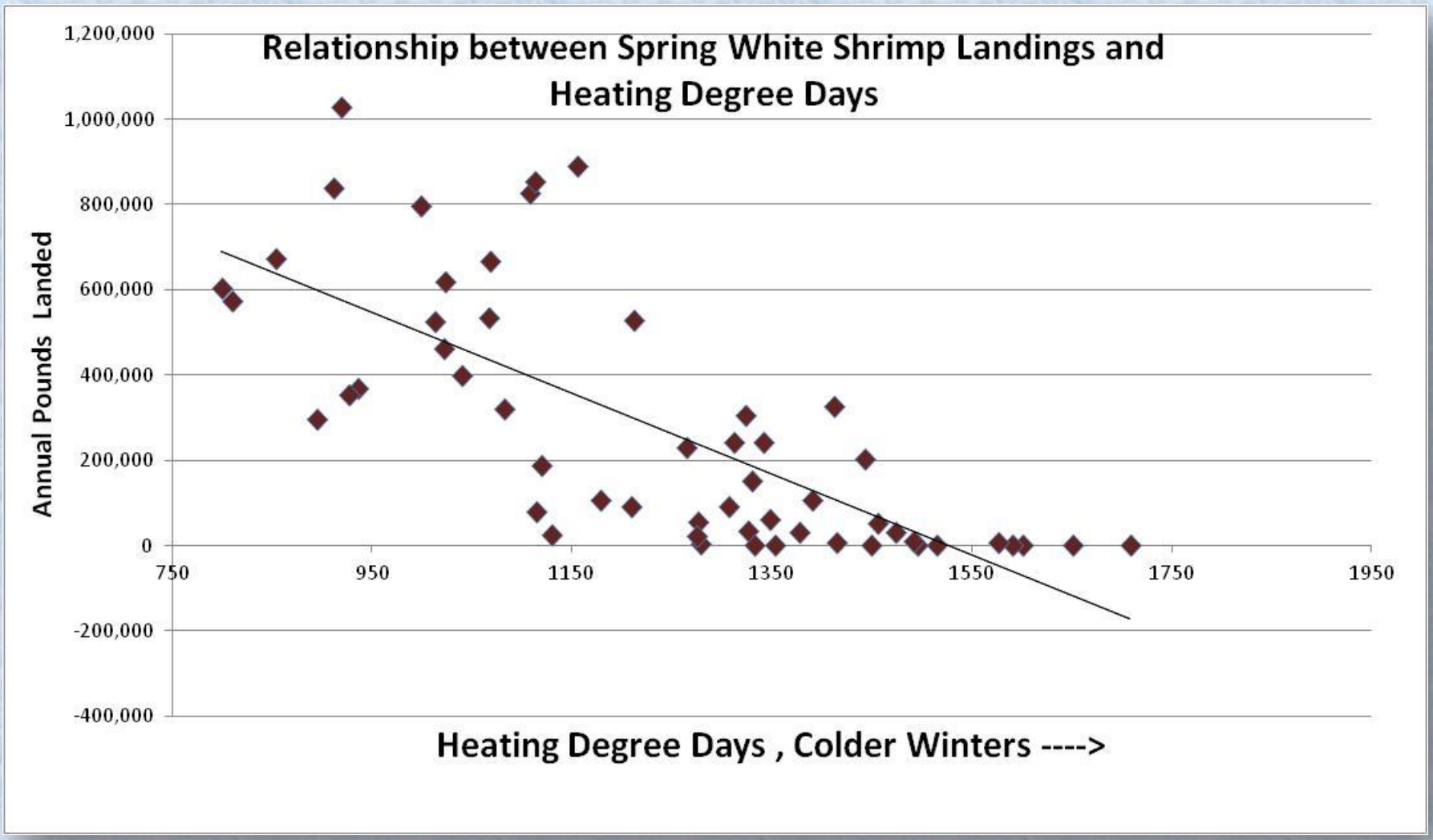
Cold-Narcotized White Shrimp With Tangled Antenna

Necrotic Tissues on White Shrimp

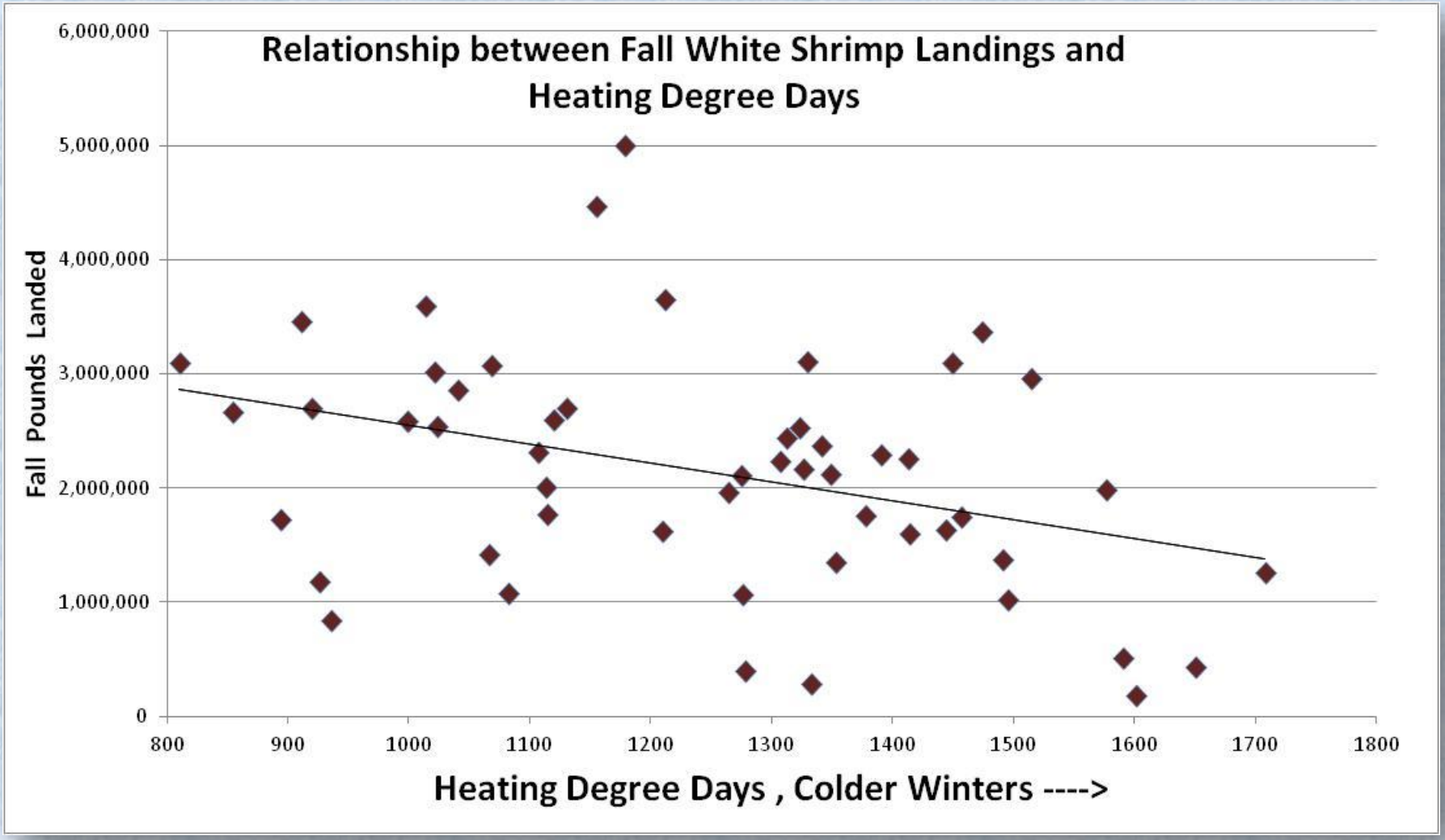
Decomposing Shrimp




White Shrimp Annual Commerical Landings (1959-2011)
Pounds
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
1959
1963
1967
1971
1975
1979
1983
1988
1992
1996
2000
2004
2008
Years

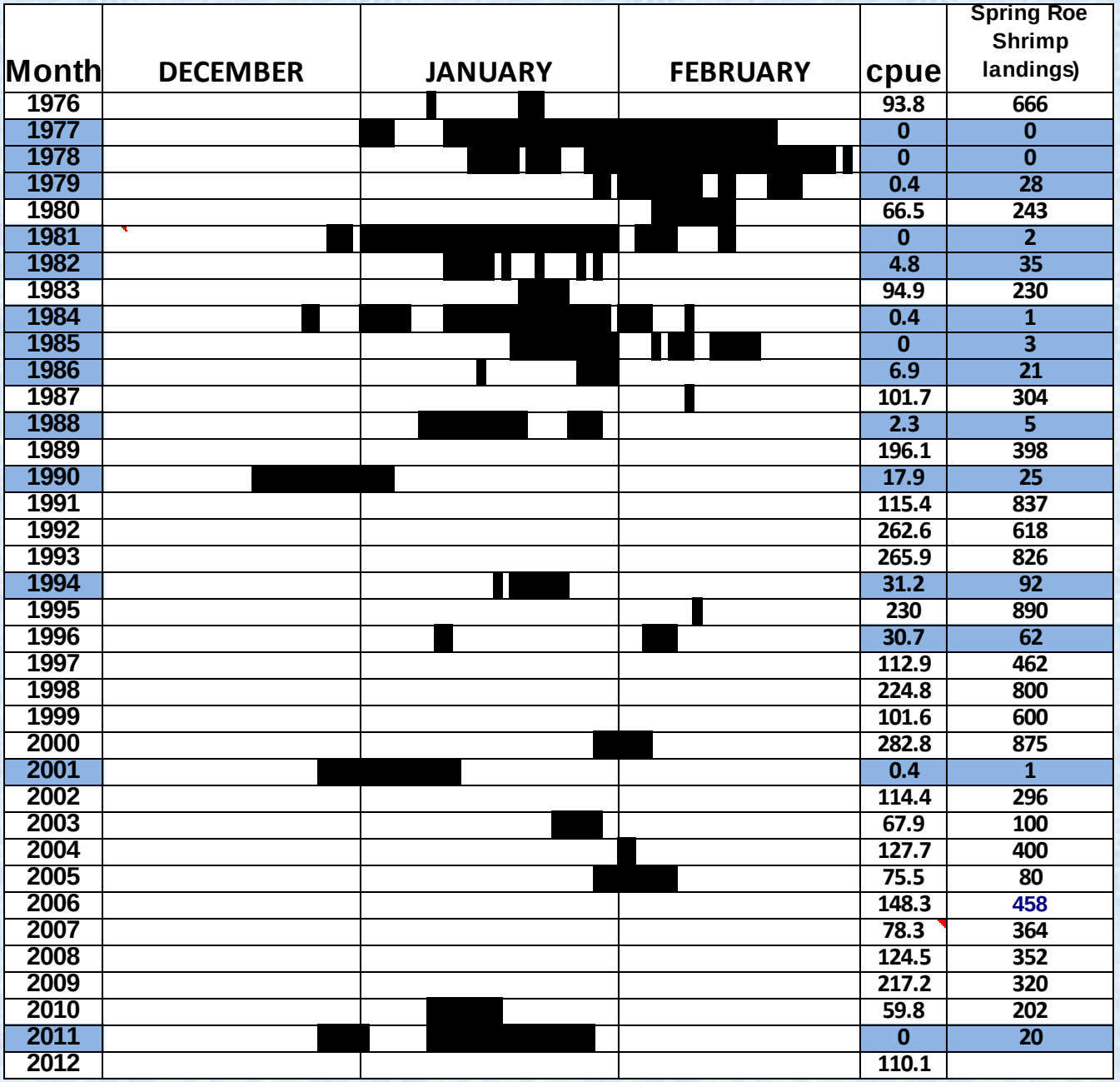


Heating Degree Days = 65°F – (mid point between daily high and low)



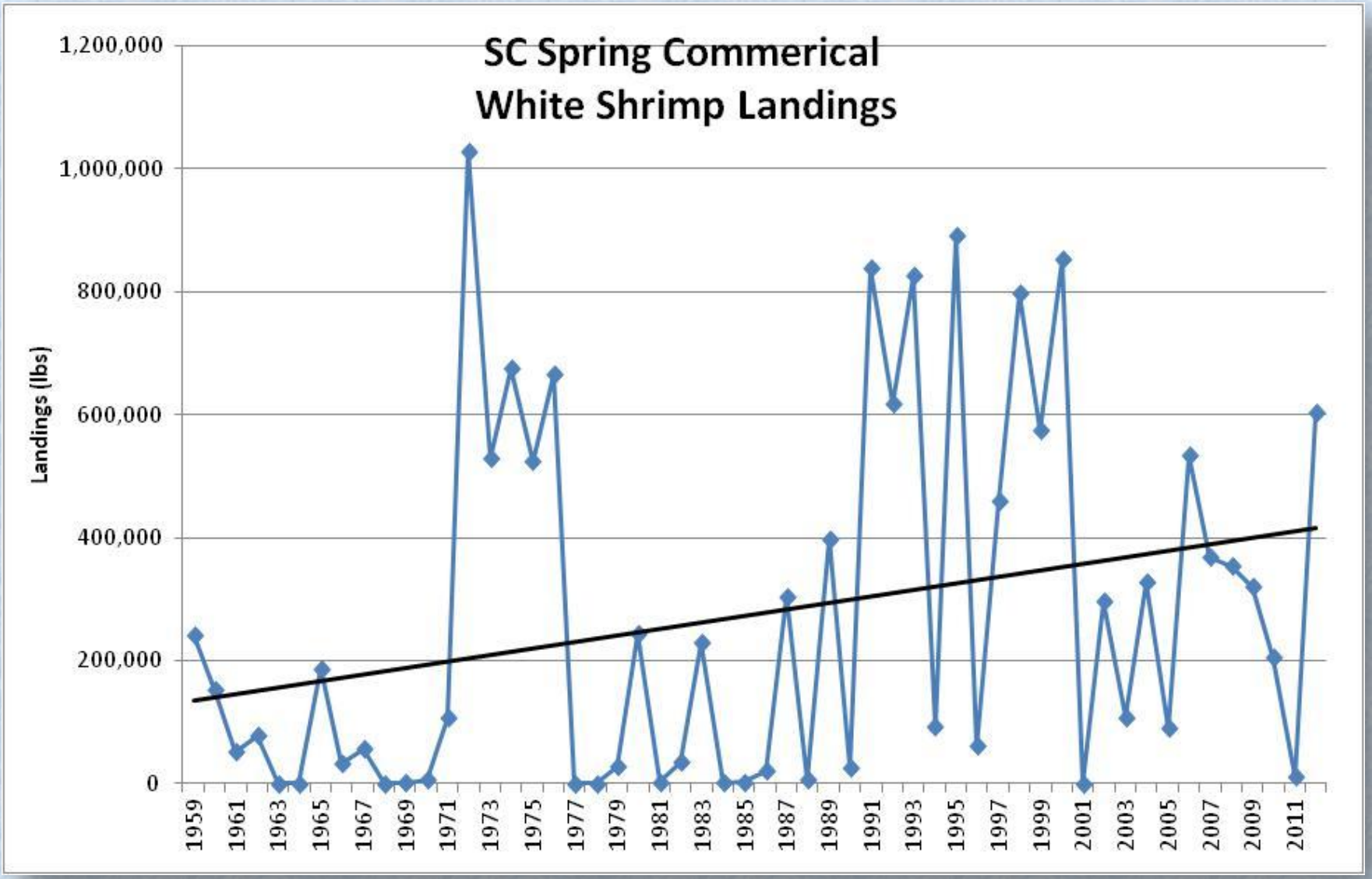
Heating Degree Days = 65°F – (mid point between daily high and low)

Days with Water Less Than 8.3°C (46.9°F)

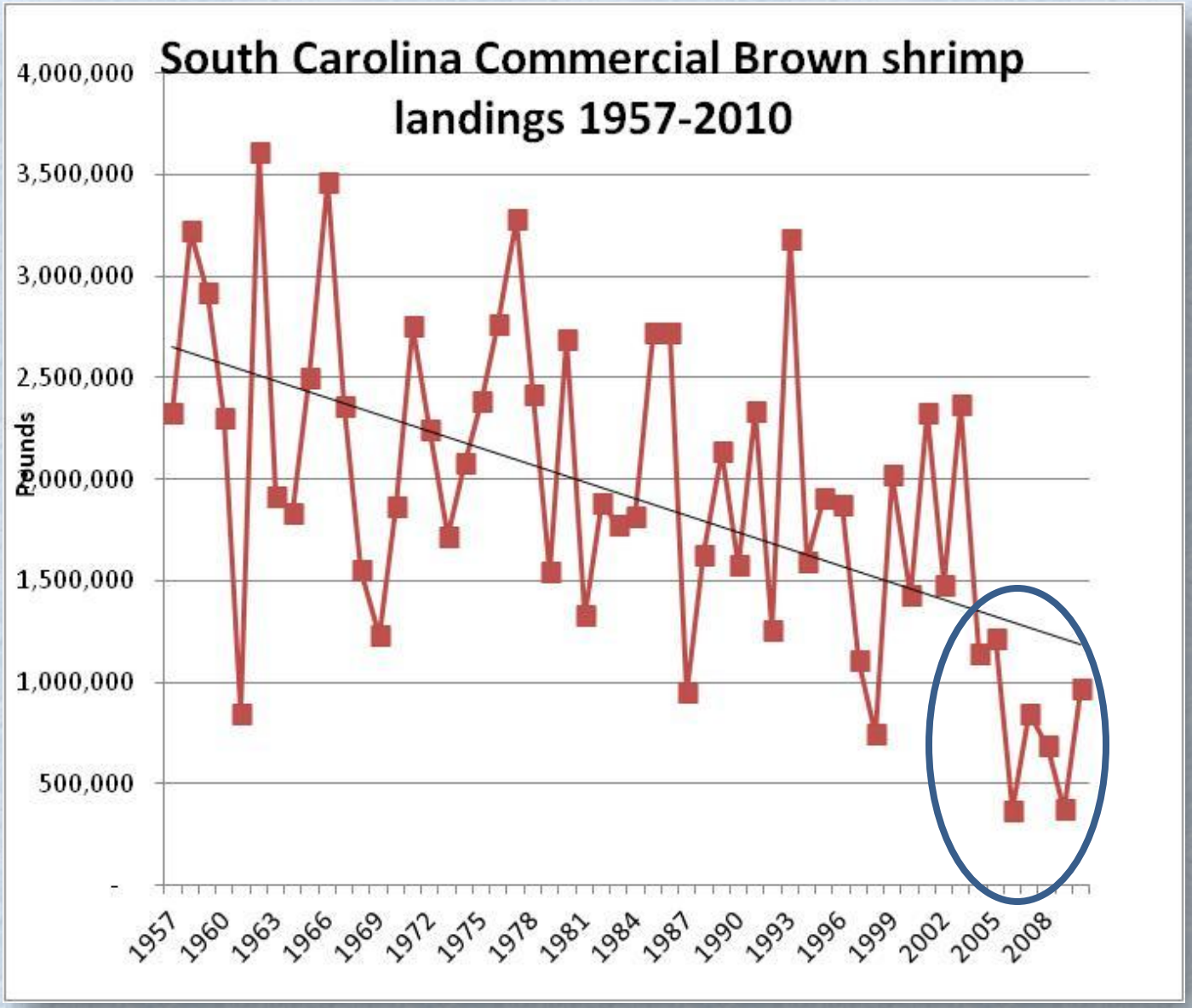


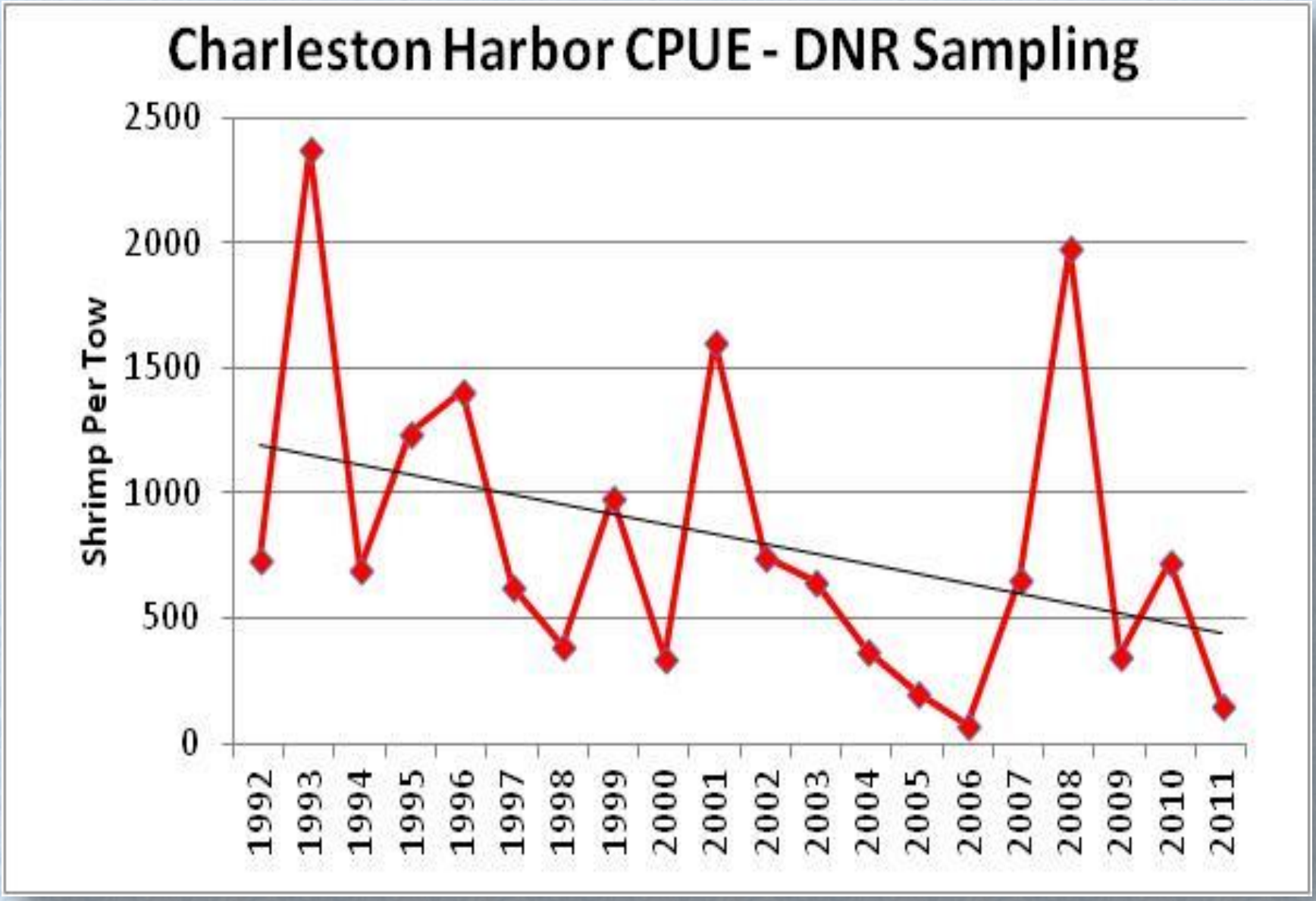
Month	DECEMBER	JANUARY	FEBRUARY	cpue	Spring Roe Shrimp landings)
1976				93.8	666
1977				0	0
1978				0	0
1979				0.4	28
1980				66.5	243
1981				0	2
1982				4.8	35
1983				94.9	230
1984				0.4	1
1985				0	3
1986				6.9	21
1987				101.7	304
1988				2.3	5
1989				196.1	398
1990				17.9	25
1991				115.4	837
1992				262.6	618
1993				265.9	826
1994				31.2	92
1995				230	890
1996				30.7	62
1997				112.9	462
1998				224.8	800
1999				101.6	600
2000				282.8	875
2001				0.4	1
2002				114.4	296
2003				67.9	100
2004				127.7	400
2005				75.5	80
2006				148.3	458
2007				78.3	364
2008				124.5	352
2009				217.2	320
2010				59.8	202
2011				0	20
2012				110.1	

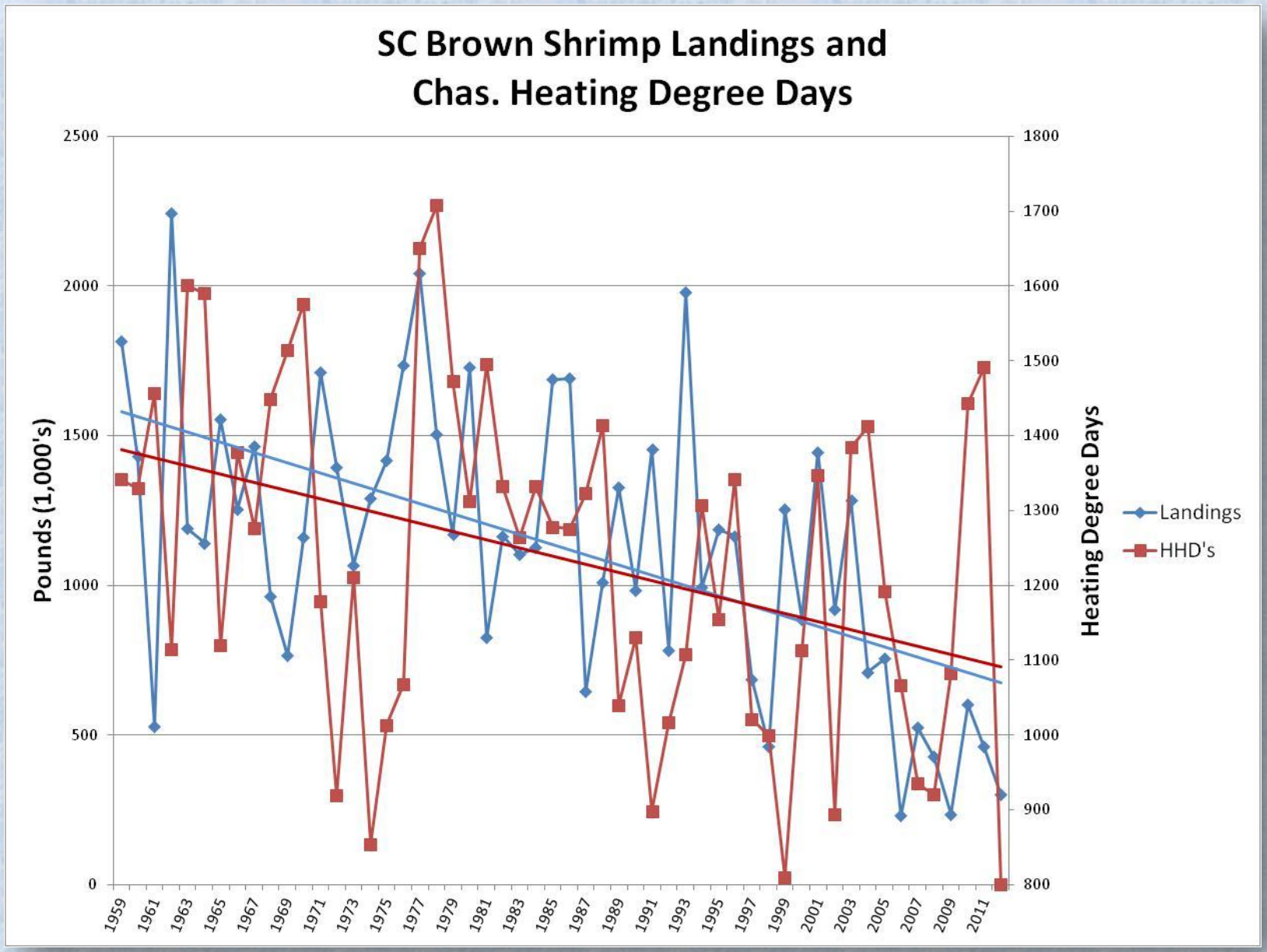
Month	DECEMBER	JANUARY	FEBRUARY	MARCH	Spring Landings (1000's Lbs)
1950					
1951					
1952					
1953					
1954					
1955					
1956					
1957					
1958					
1959					240
1960					151
1961					52
1962					79
1963					0
1964					0
1965					187
1966					32
1967					56
1968					0
1969					1
1970					6
1971					106
1972					1029
1973					528
1974					674
1975					525
1976					666
1977					0
1978					0
1979					28
1980					243
1981					2
1982					35
1983					230
1984					1
1985					3
1986					21
1987					304
1988					5
1989					398
1990					25
1991					837
1992					618
1993					826
1994					92
1995					890
1996					62
1997					462
1998					800
1999					600
2000					875
2001					1
2002					296
2003					100
2004					400
2005					80
2006					458
2007					364
2008					352
2009					320
2010					202
2011					20
2012					650


SC Spring Commerical
White Shrimp Landings
Landings (lbs)
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011

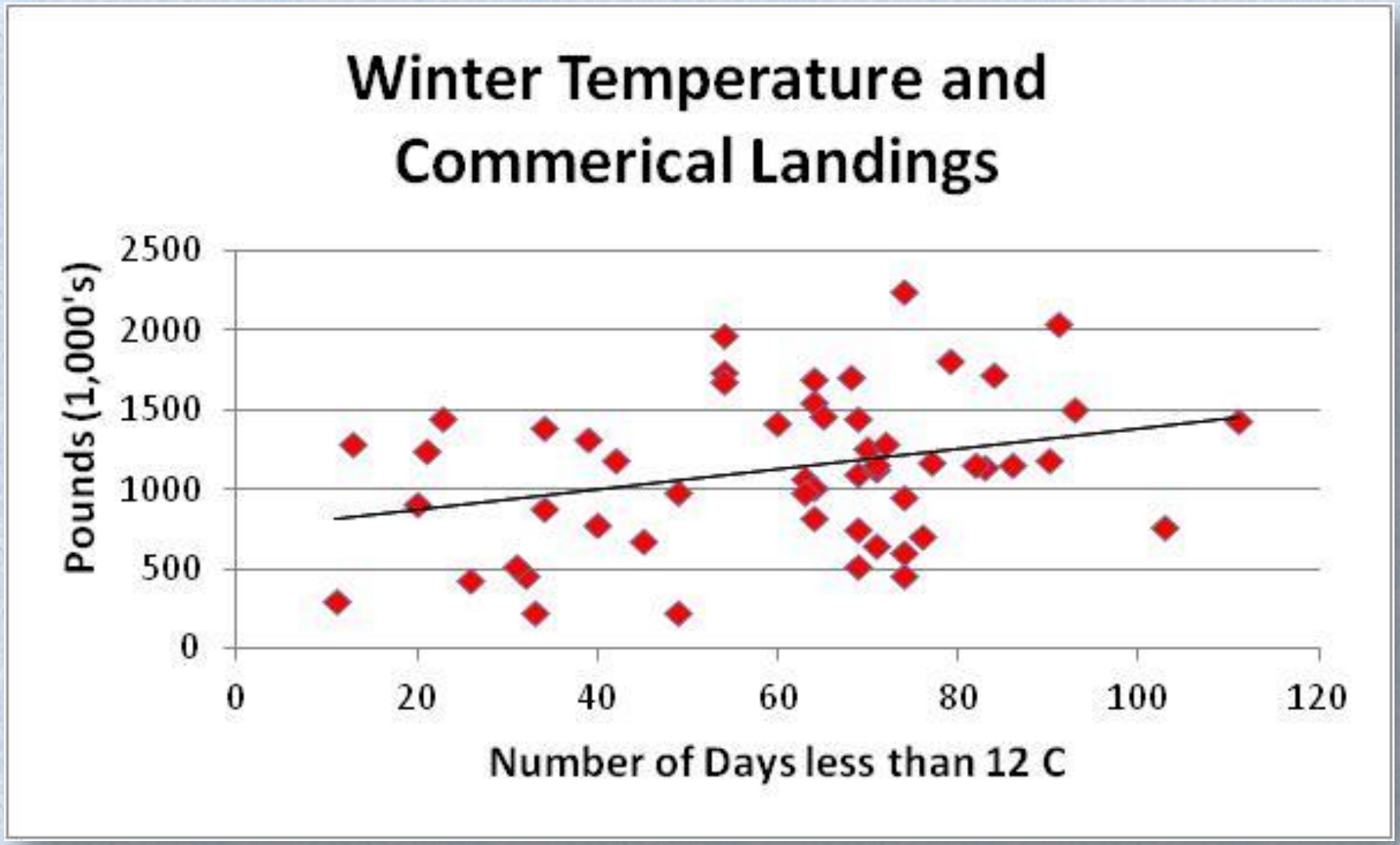
Brown Shrimp


South Carolina Commercial Brown shrimp landings 1957-2010
Pounds
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
-
1957
1960
1963
1966
1969
1972
1975
1978
1981
1984
1987
1990
1993
1996
1999
2002
2005
2008

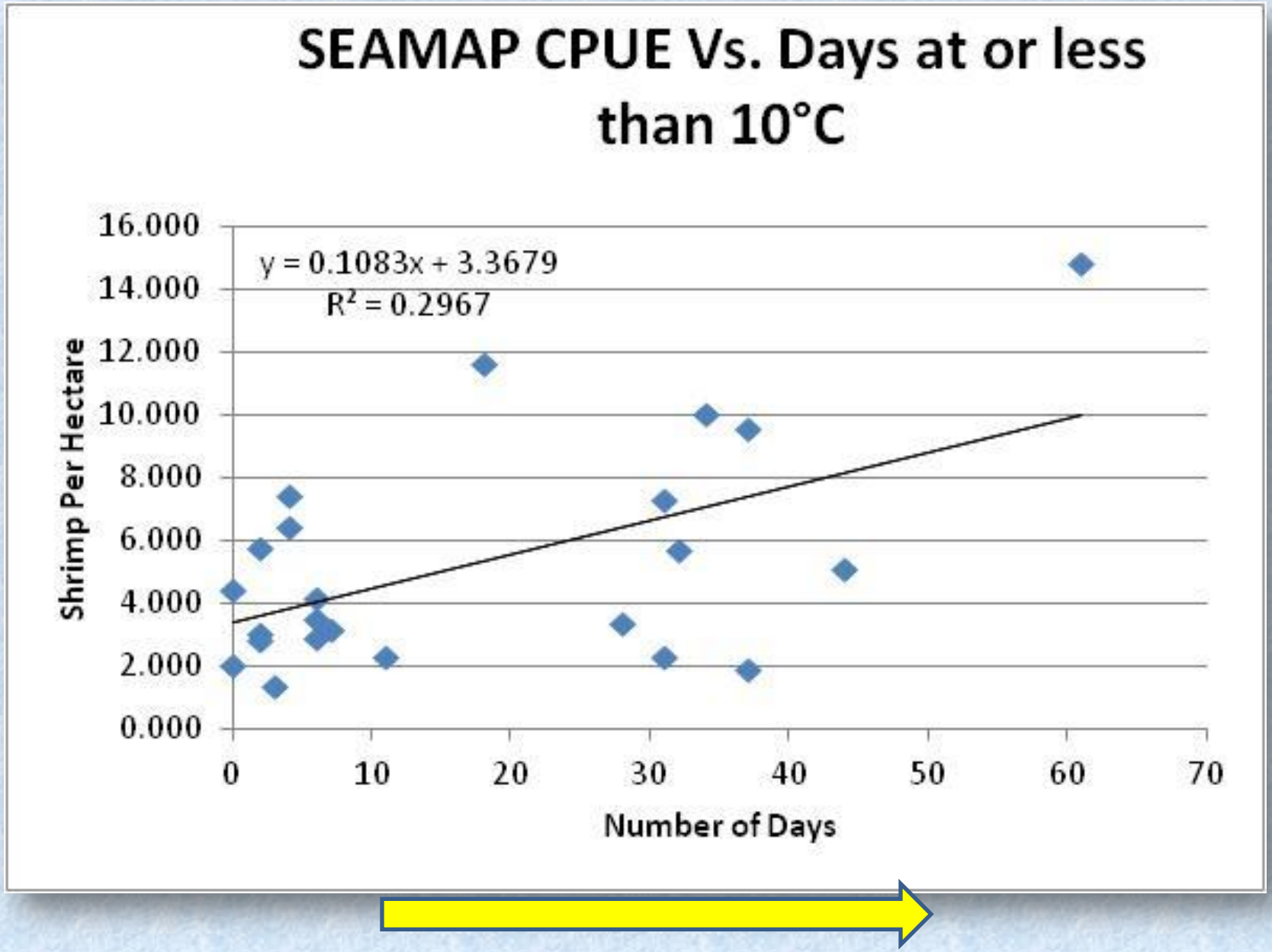

Charleston Harbor CPUE - DNR Sampling
Shrimp Per Tow
2500
2000
1500
1000
500
0
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011



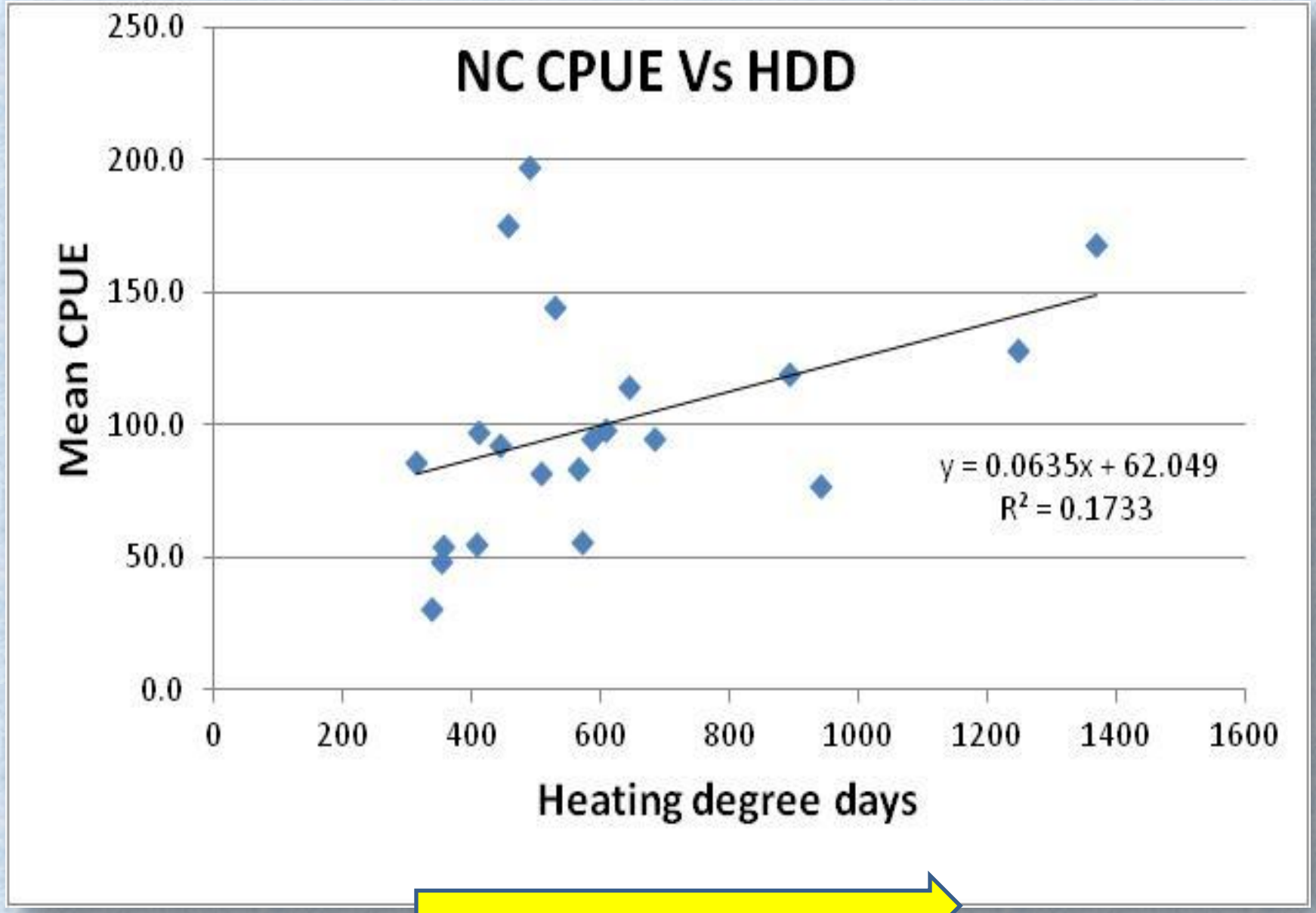
Heating Degree Days = 65°F – (mid point between daily high and low)



Colder Winters



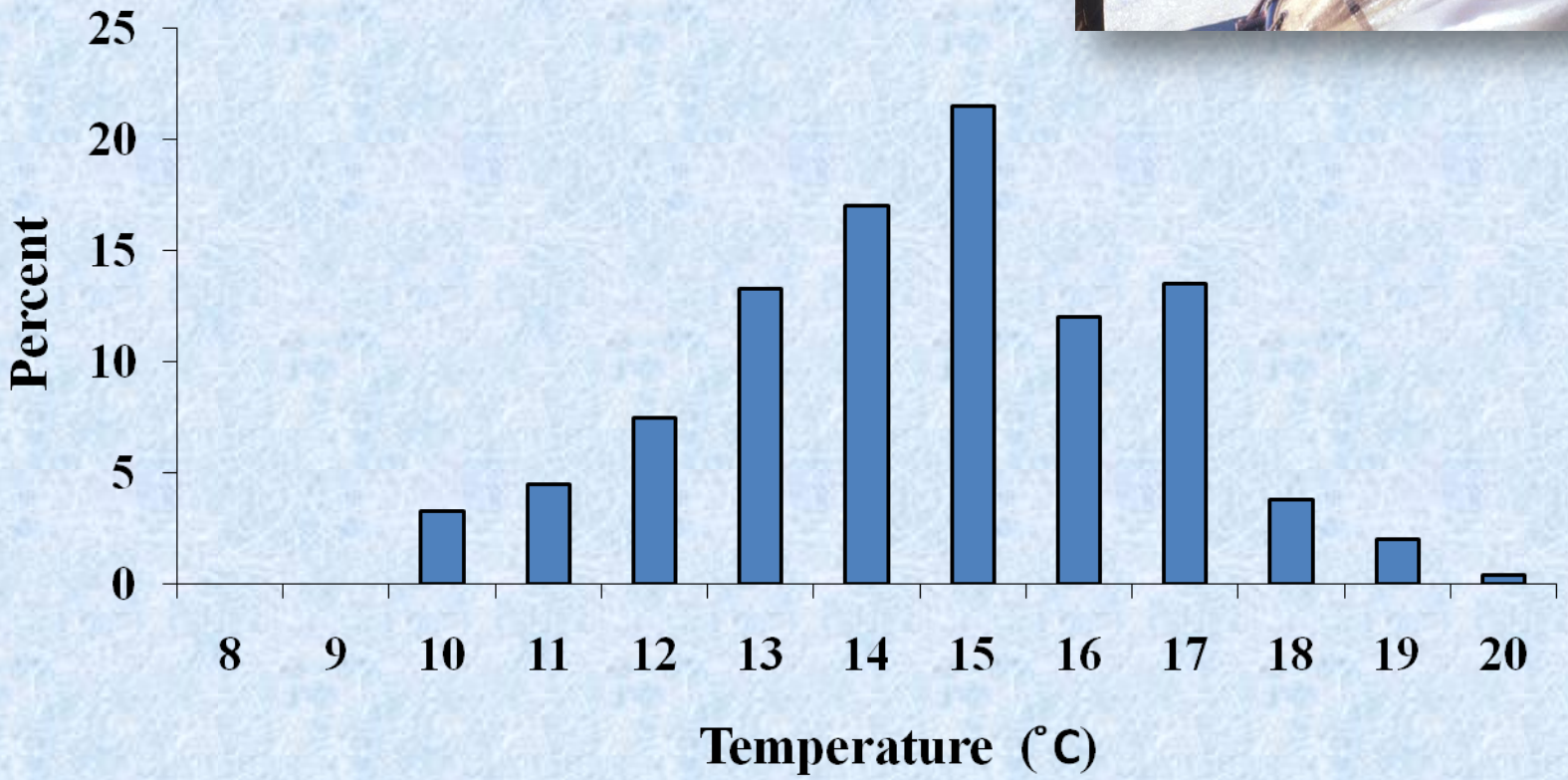
Colder Winters

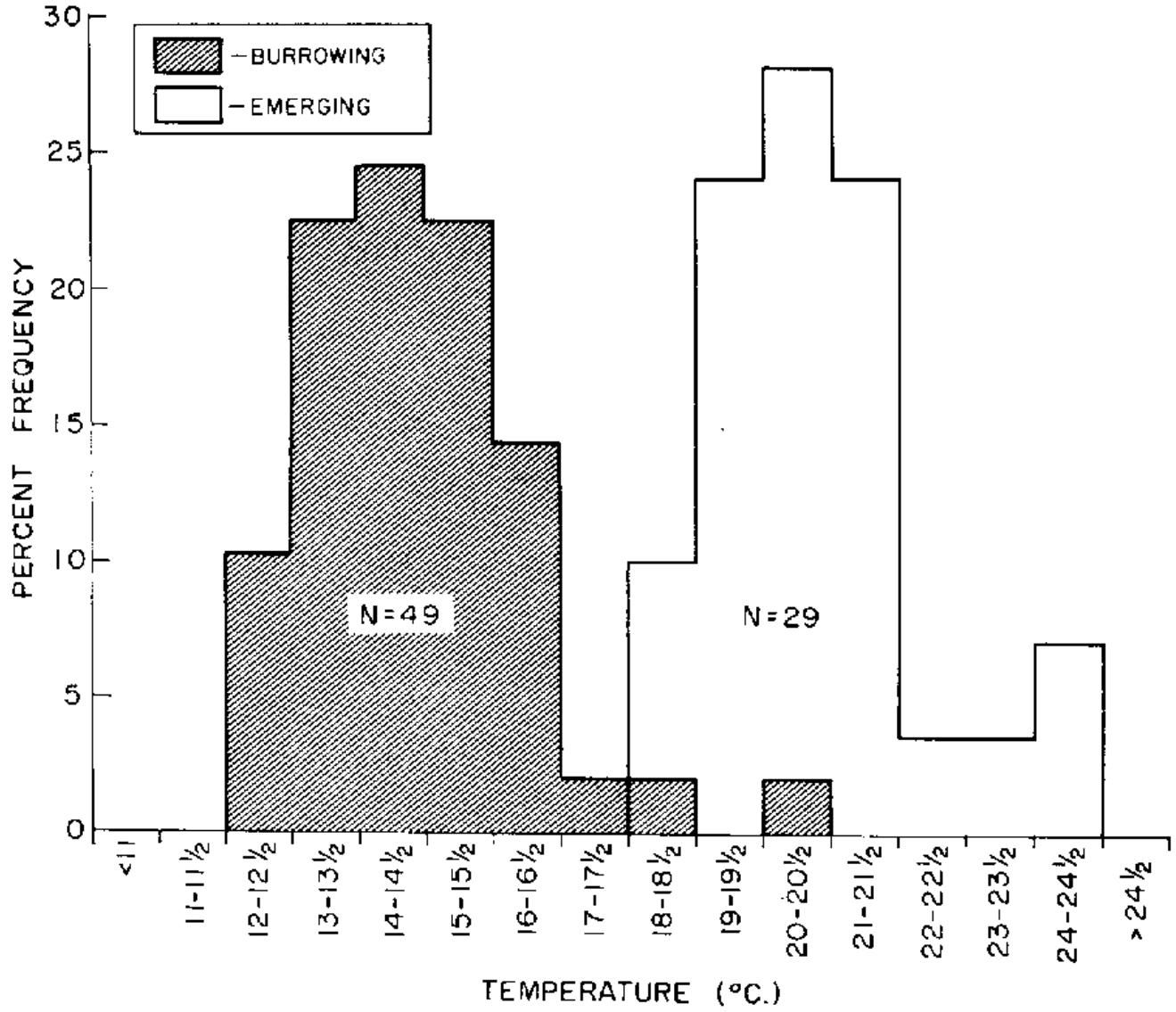


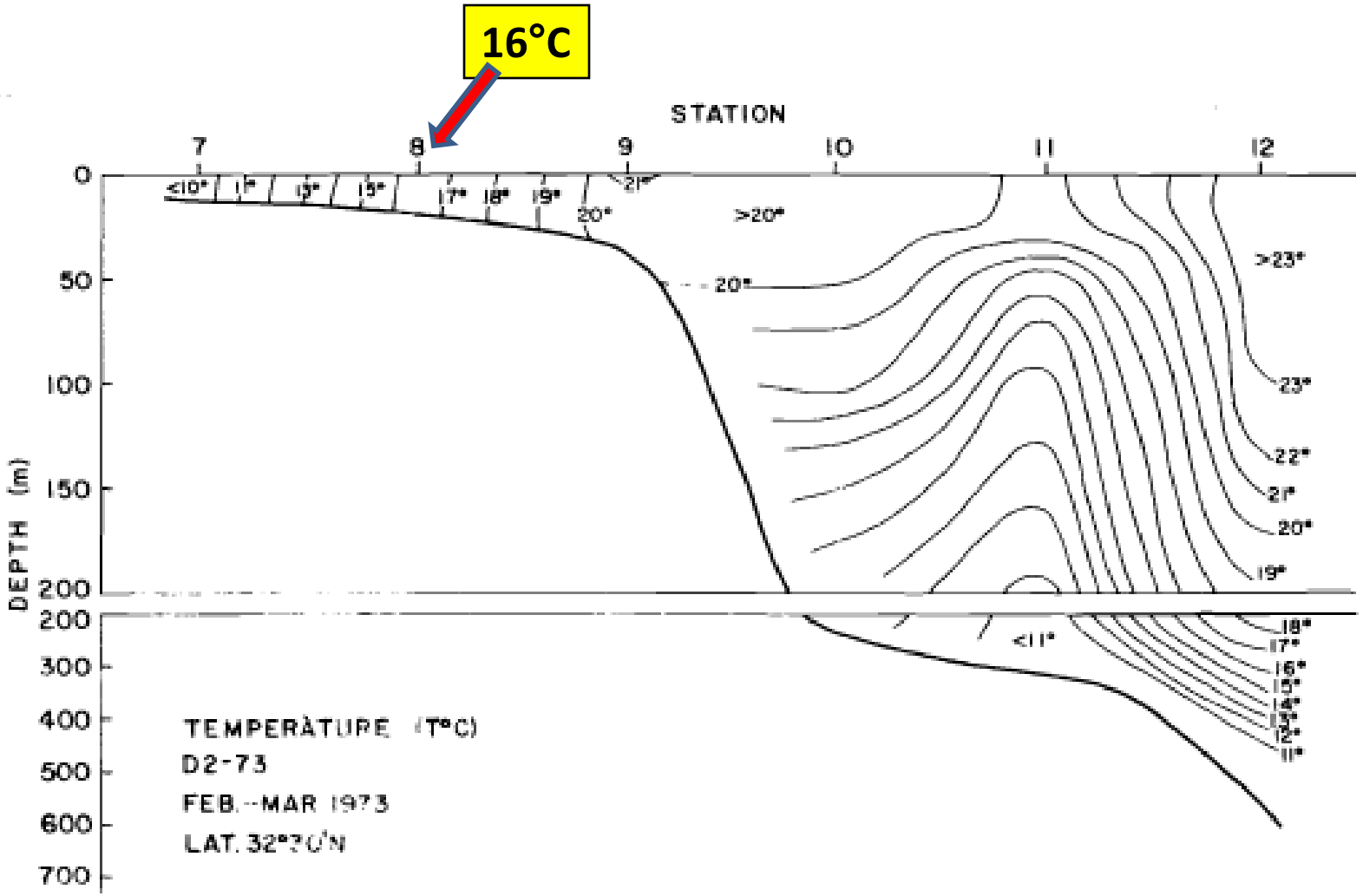
Colder Winters

Postlarval Shrimp CPUE as Related to Temperature

(534 samples from 1975 to 1992)

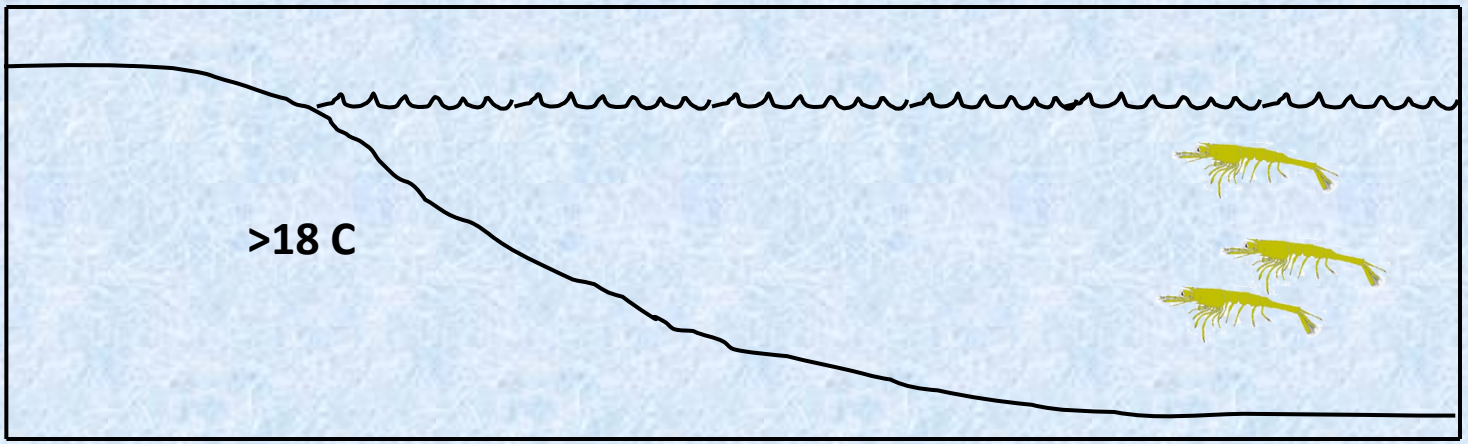


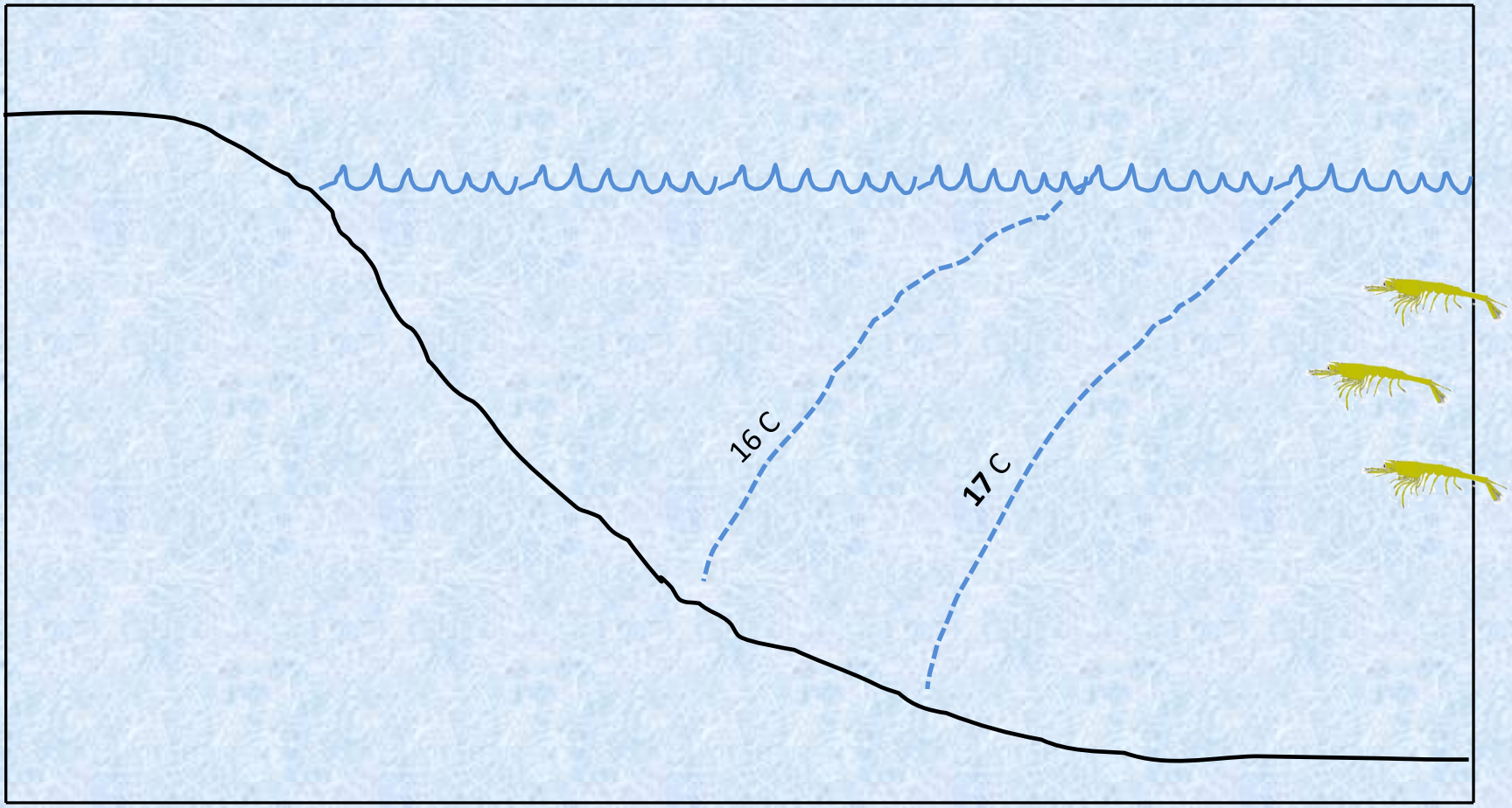

BURROWING
EMERGING
PERCENT FREQUENCY
30
25
20
15
10
5
0
N=49
N=29
<11
11-11½
12-12½
13-13½
14-14½
15-15½
16-16½
17-17½
18-18½
19-19½
20-20½
21-21½
22-22½
23-23½
24-24½
>24½
TEMPERATURE (°C.)



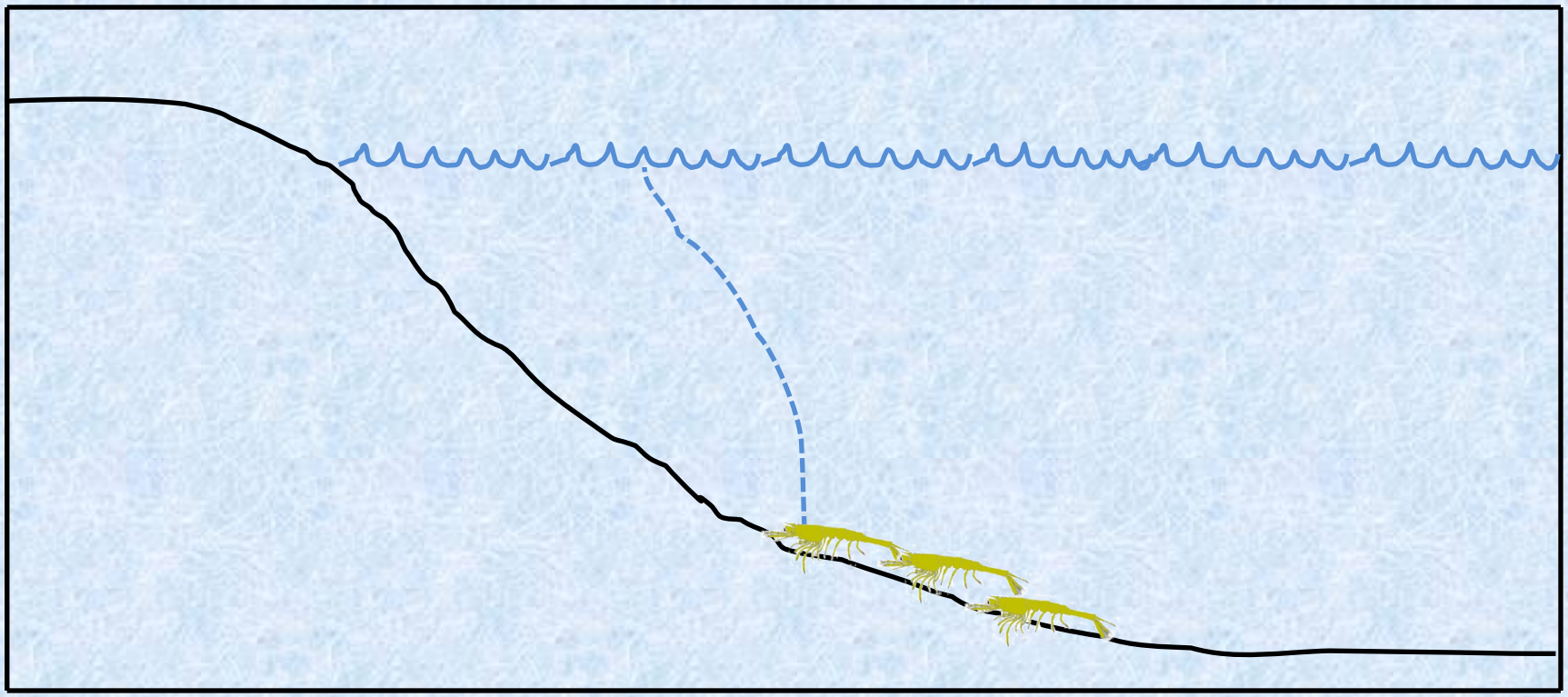
Continental Shelf Temperature Cross-section off Charleston, 1973.

Some postlarvae approach the shore and enter Estuaries prior to winter temperatures

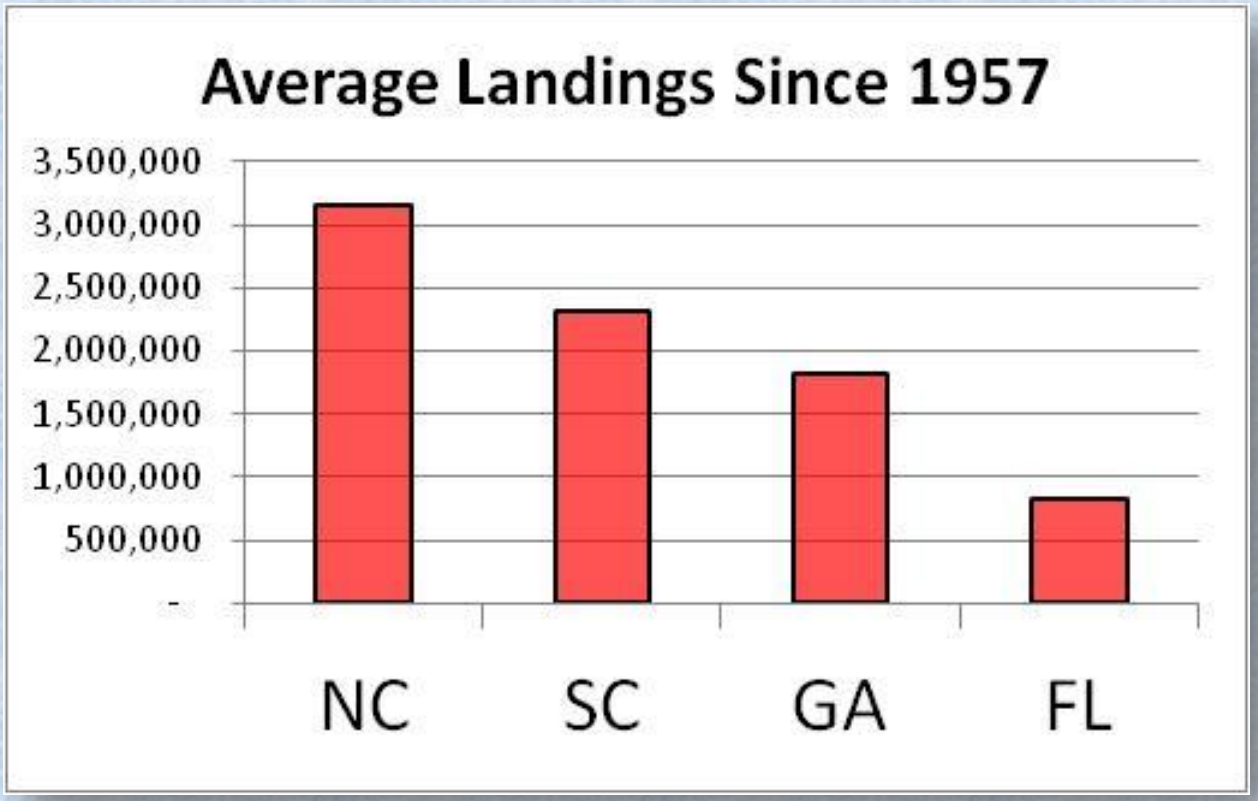




Postlarvae drop to the bottom and bury as water temperatures decline in December or January



Postlarvae Re-enter Water Column with Warming Temperatures in March

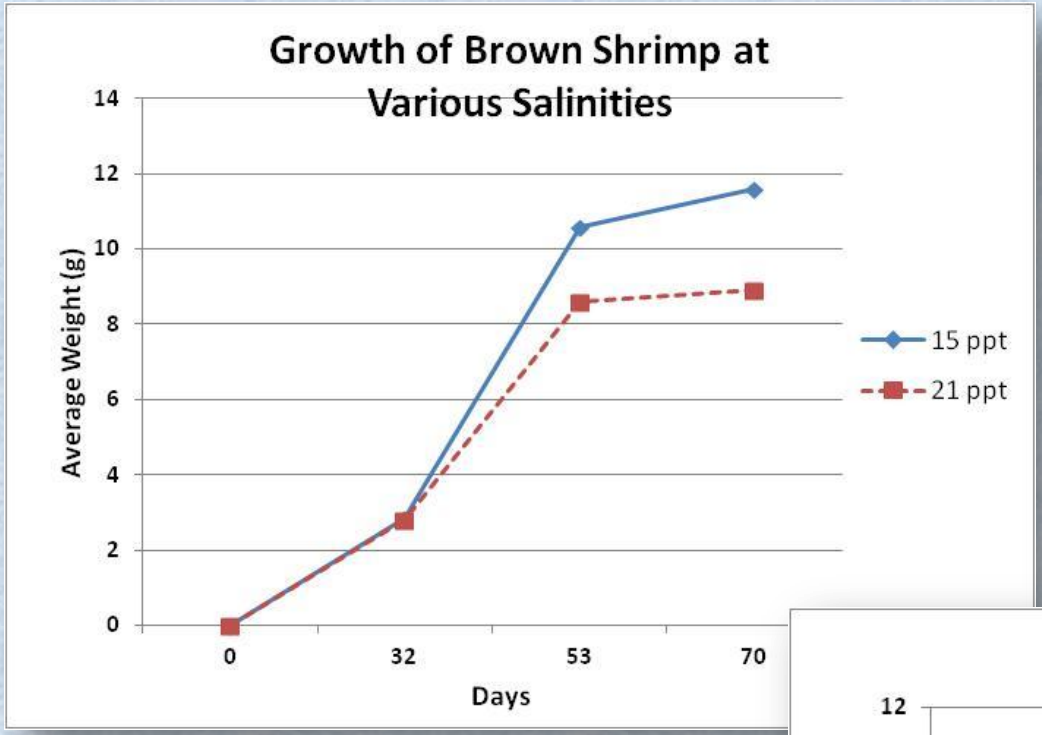

Average Landings Since 1957
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
-
NC
SC
GA
FL

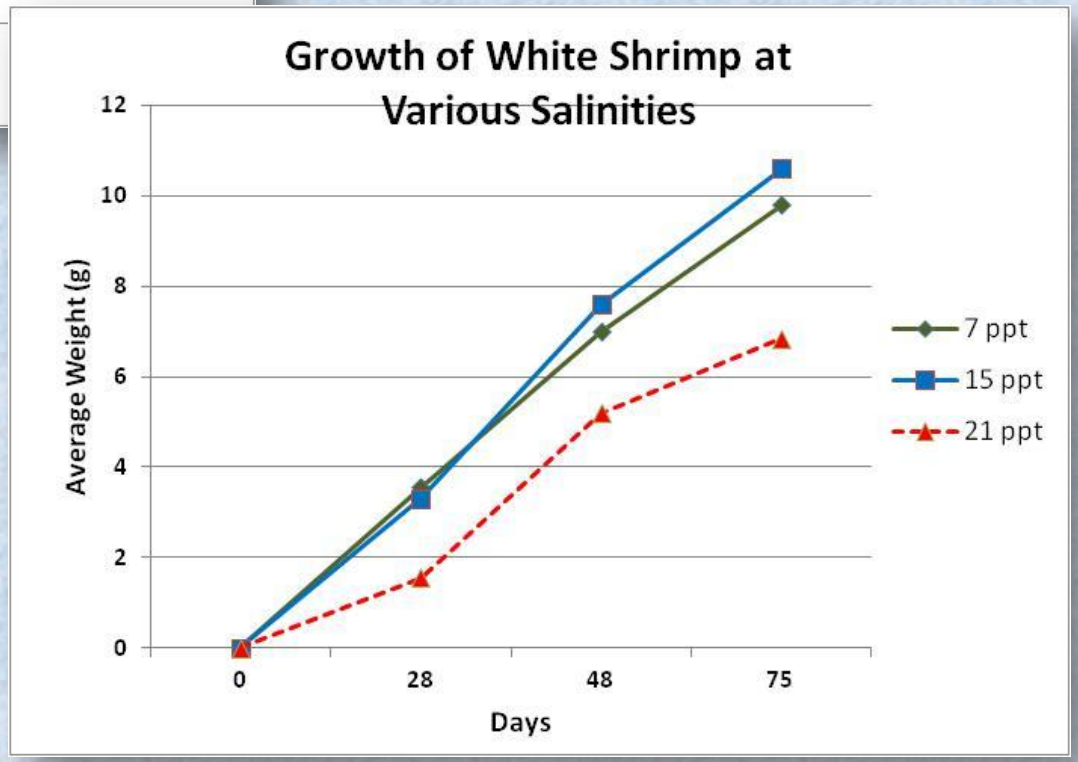
Salinity Change

Optimal Salinities for Juvenile Shrimp?

- White Shrimp - 8 to 12 ppt
- Brown shrimp - 12- 18 ppt

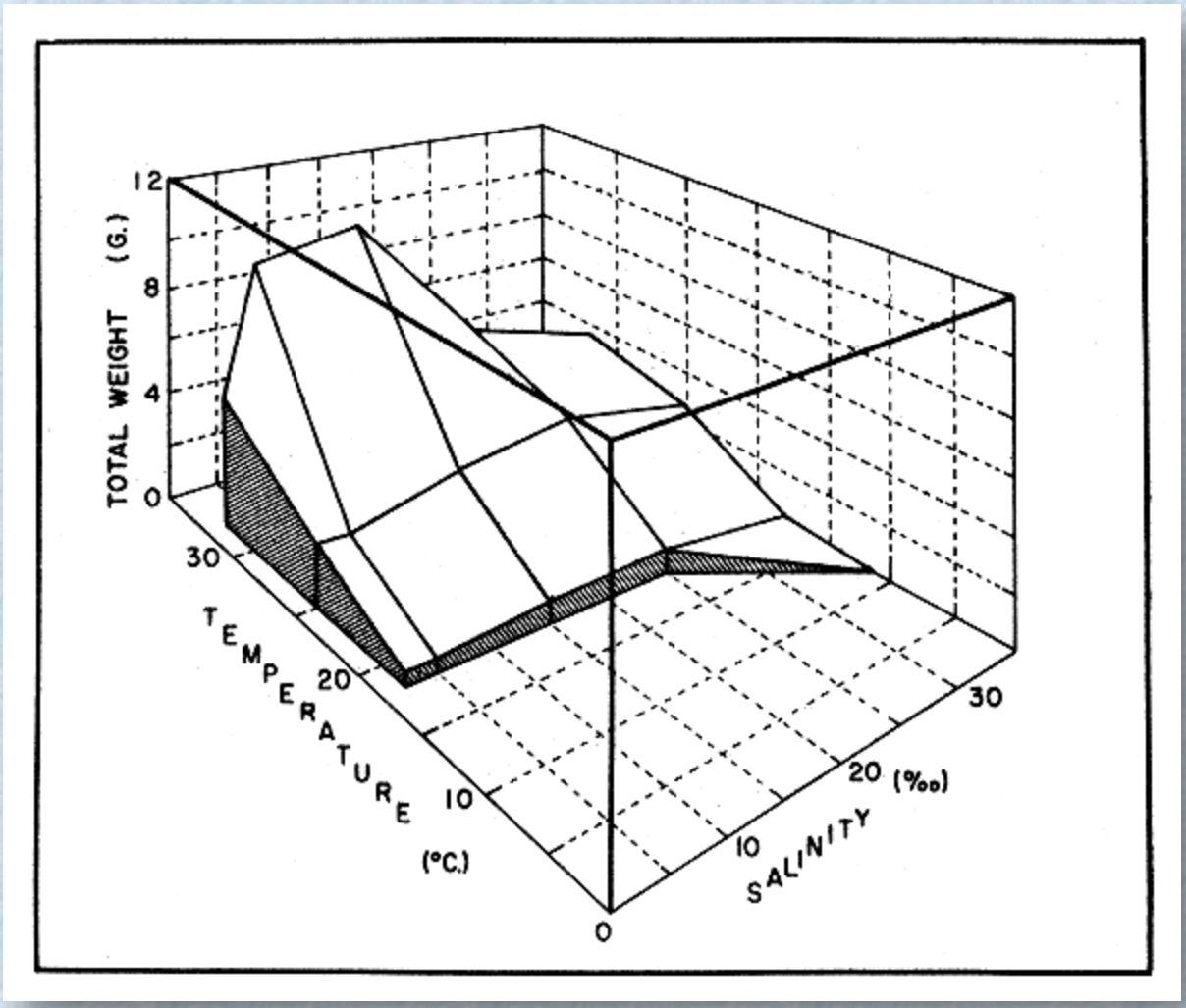
(Full Strength Seawater = 35 ppt)





(Hysmith and Colura, 1976)

Effects of temperature and salinity on postlarval white shrimp



Zein-Eldin and Griffith, 1969

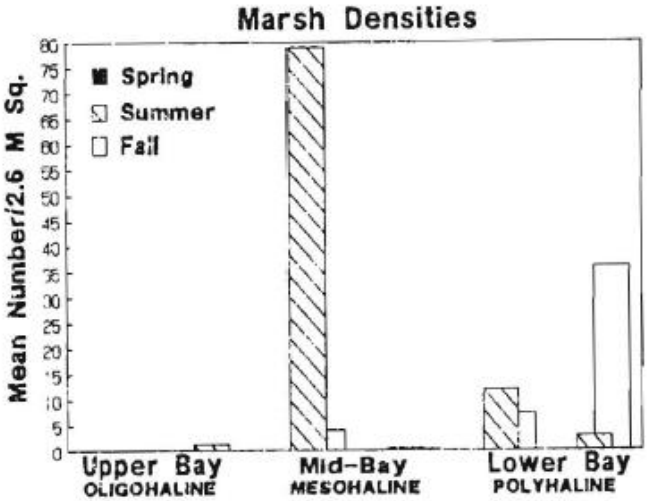
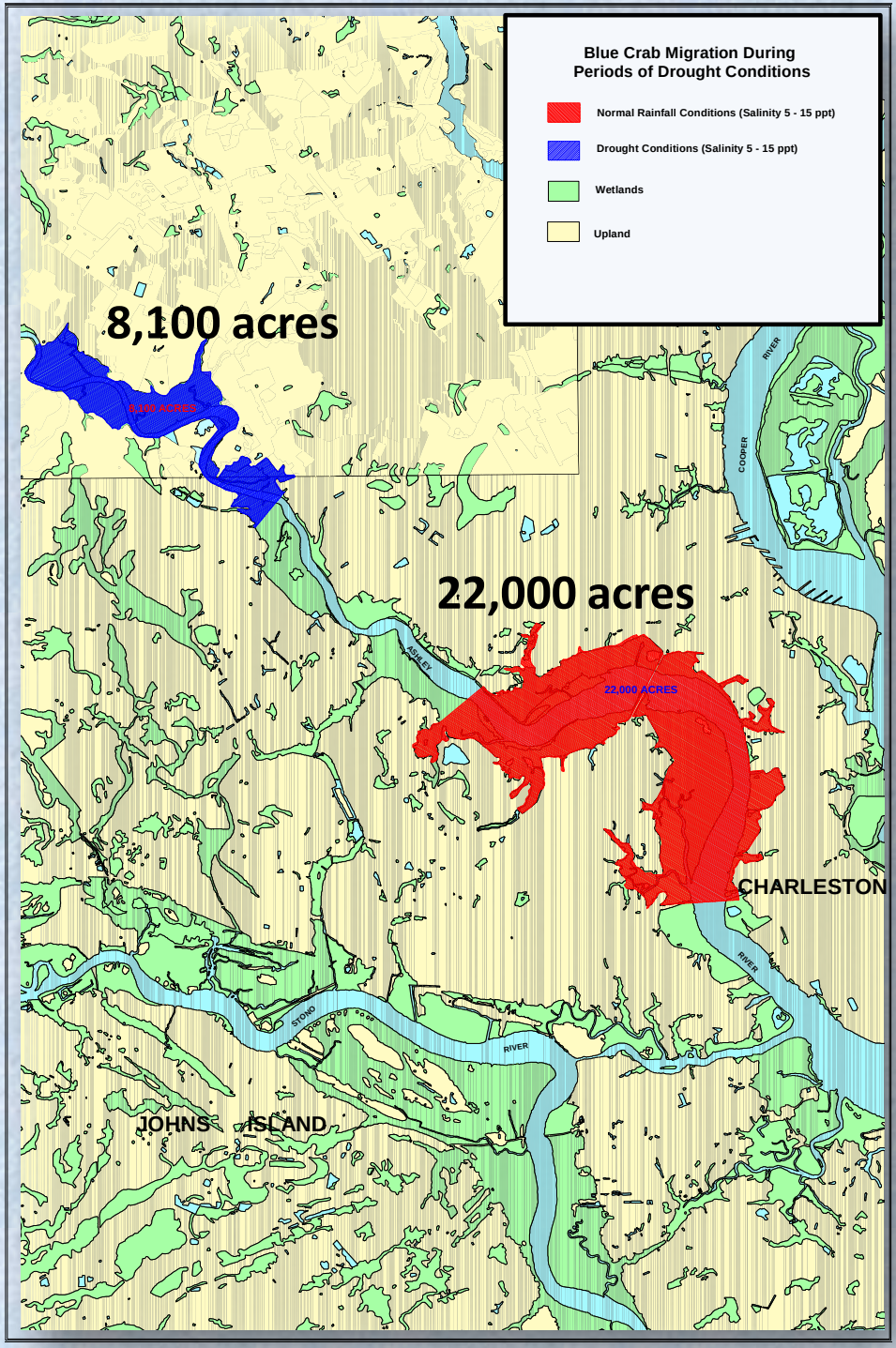


FIGURE 10. Densities of white shrimp (*Penaeus setiferus*) in marsh and adjacent nonvegetated habitats at sites along a salinity gradient in Galveston Bay.

(Zimmerman, et al. 1990. NOAA Tech. Memo. NFMS-SMFS-SEFC-250)

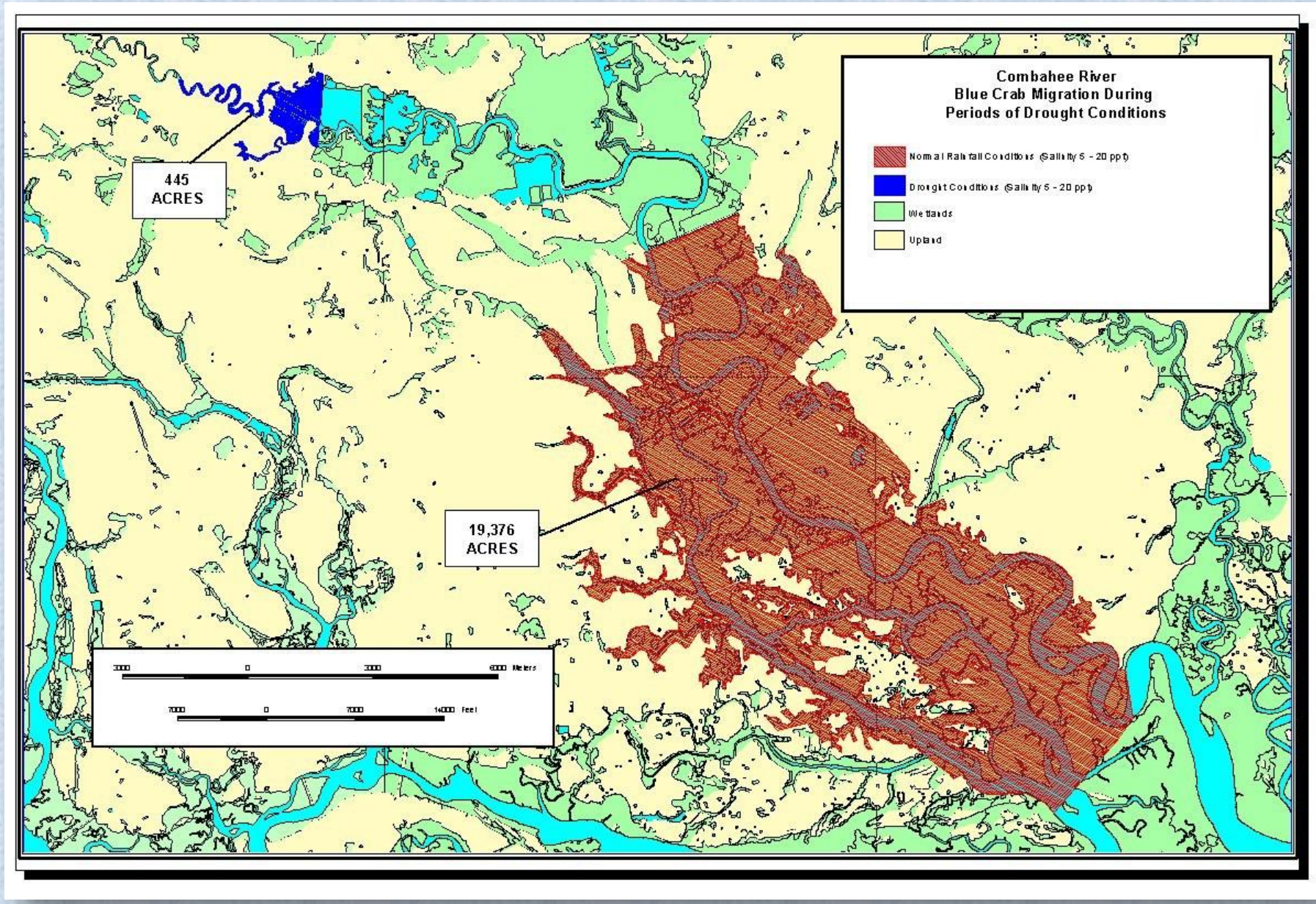


Ashley River

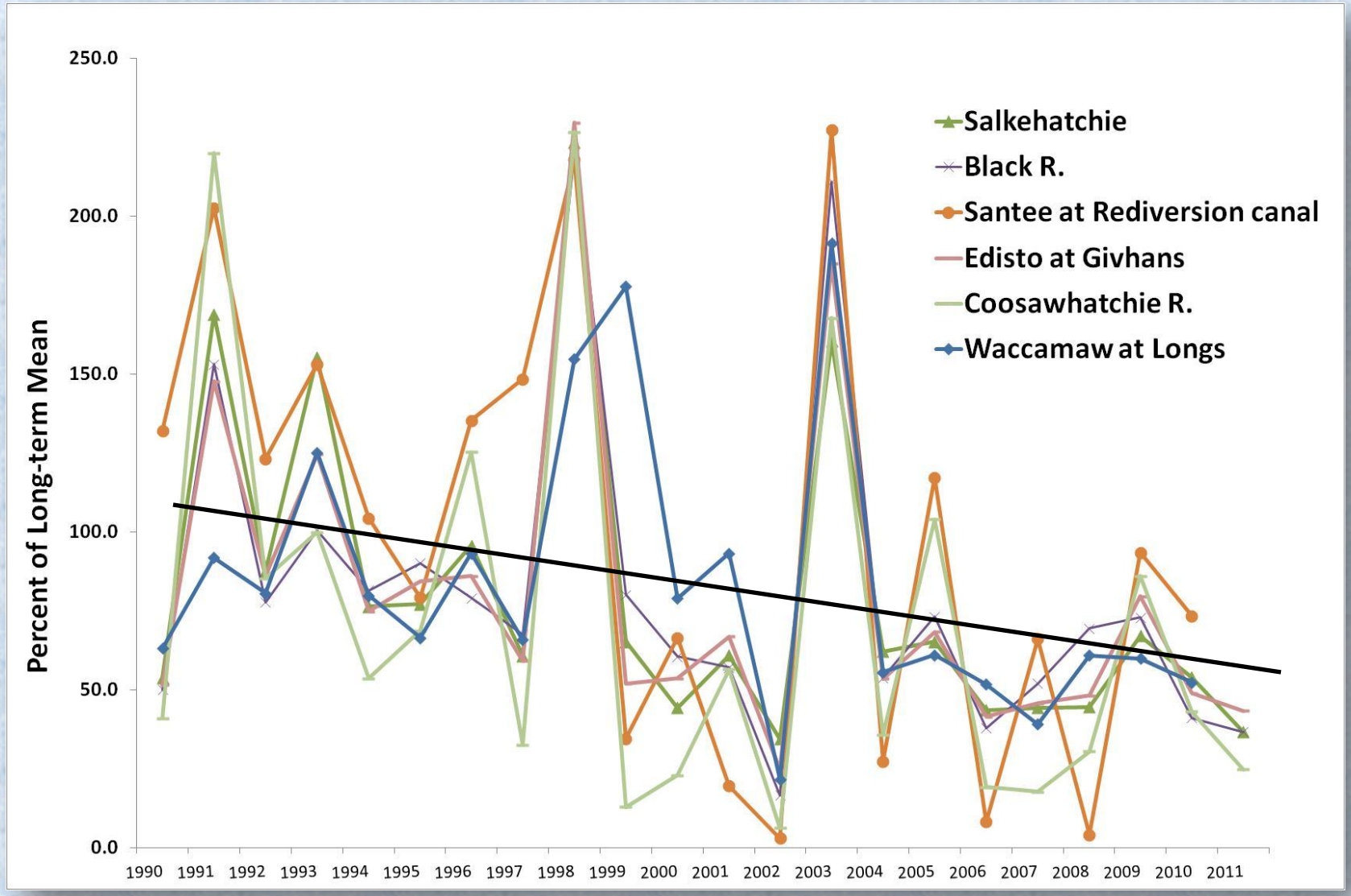
5-15 ppt Salinity Zone

Red= Normal

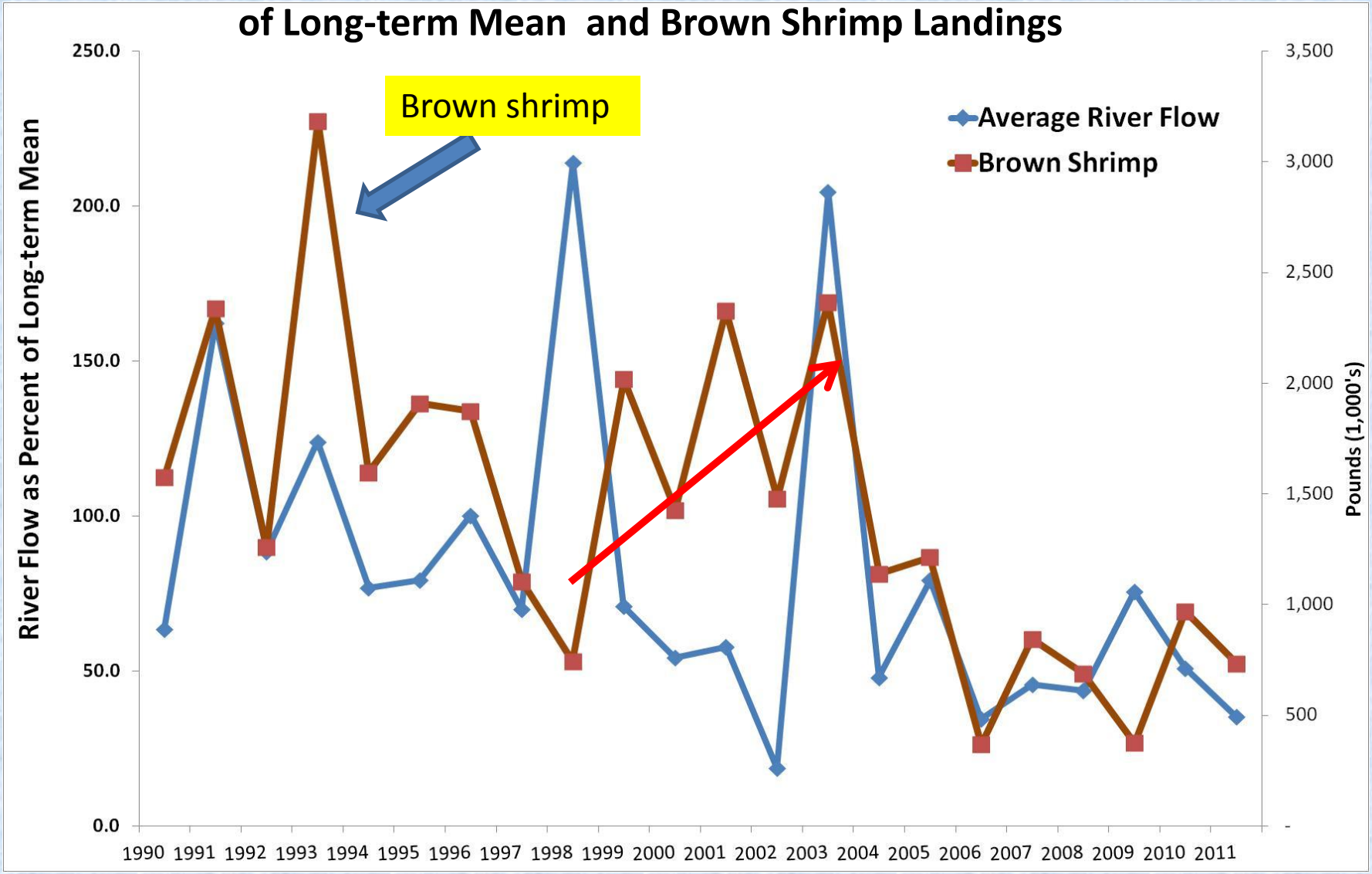
Blue=Drought

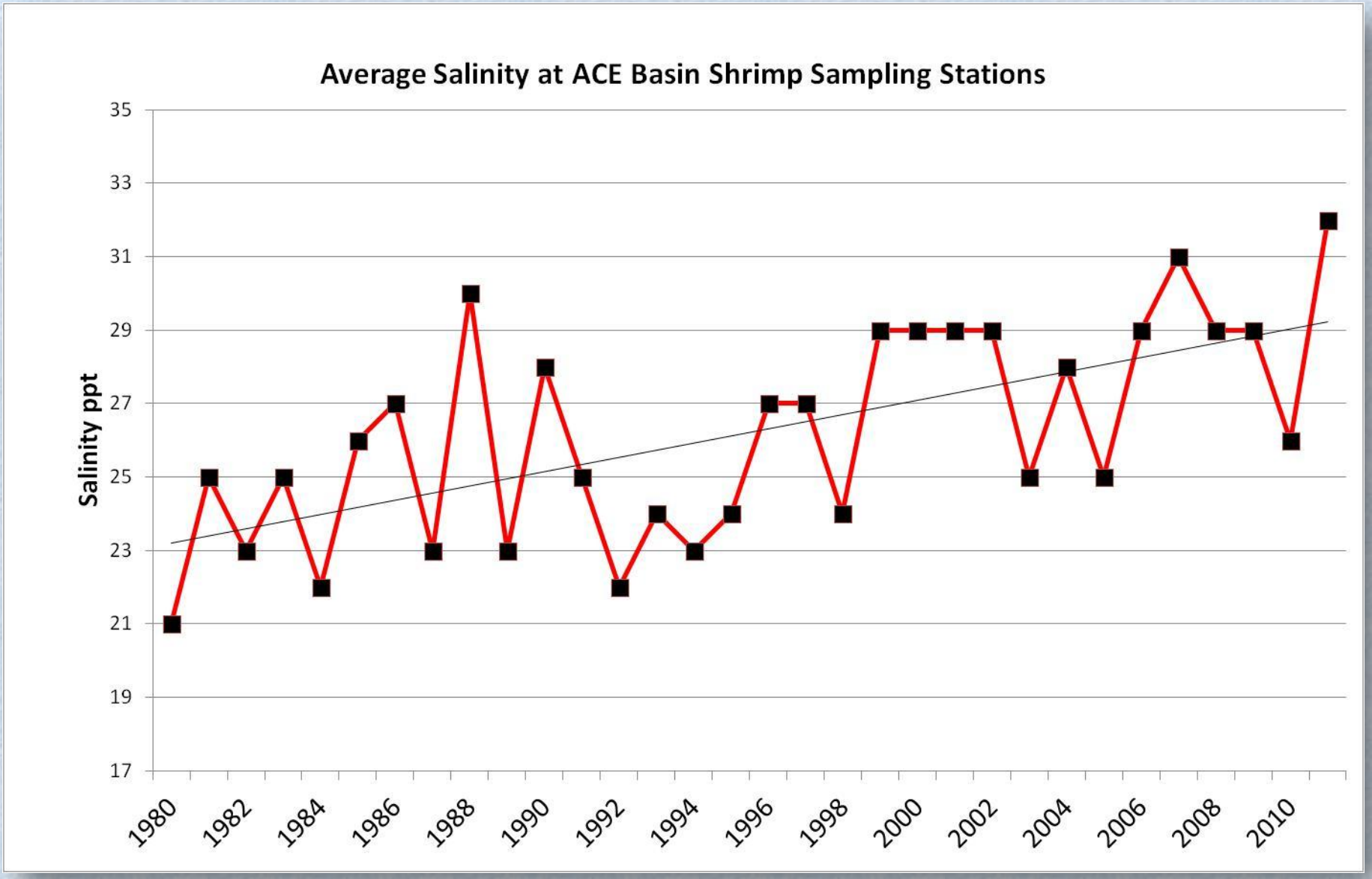

Combahee River
Blue Crab Migration During
Periods of Drought Conditions
Normal Rainfall Conditions (Salinity 5 - 20 ppt)
Drought Conditions (Salinity 5 - 20 ppt)
Wetlands
Upland
445
ACRES
19,376
ACRES
3000
0
3000
6000 Meters
7000
0
7000
14000 Feet

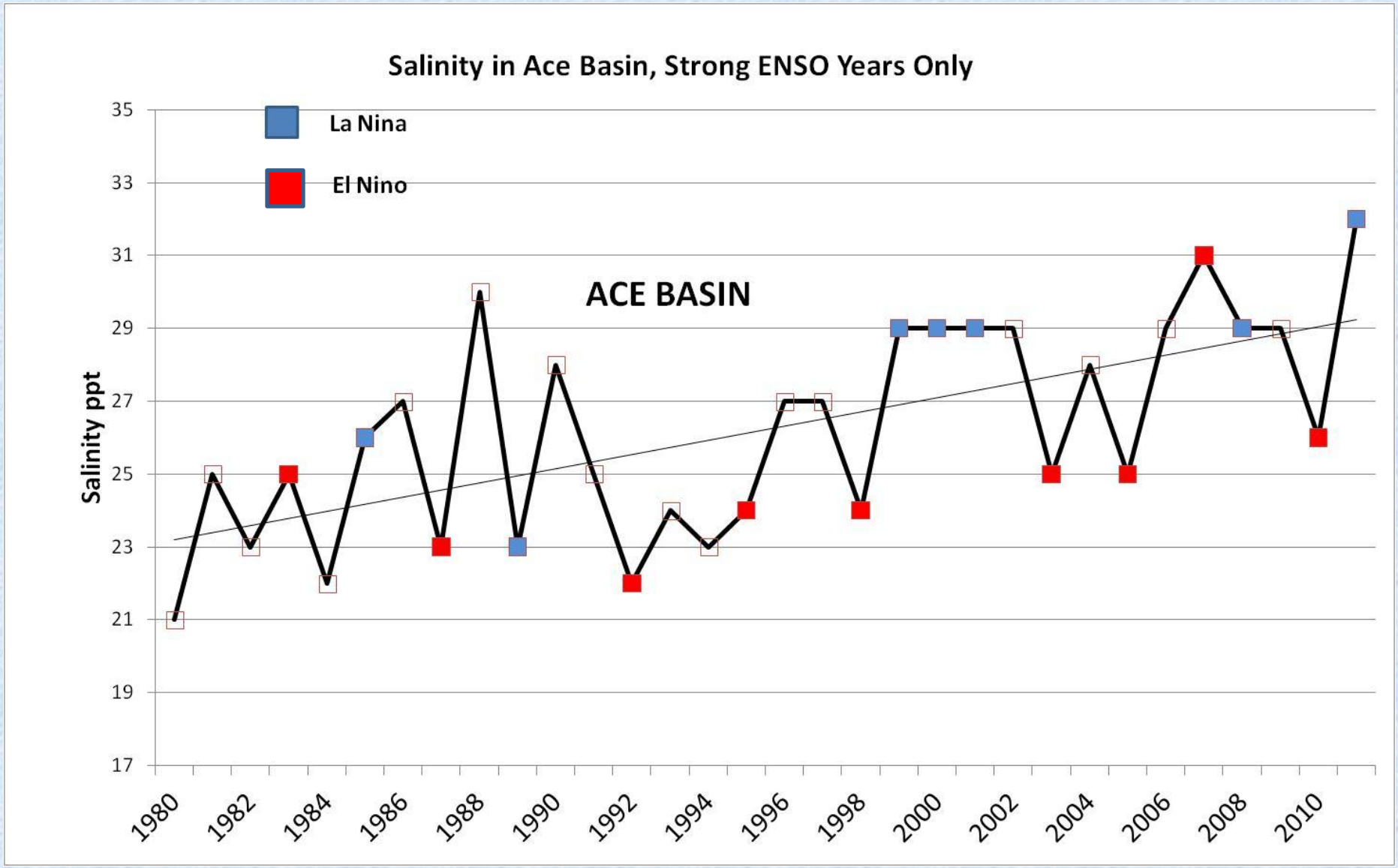
March-April River Discharge Shown as Percentage of Long-Term Mean

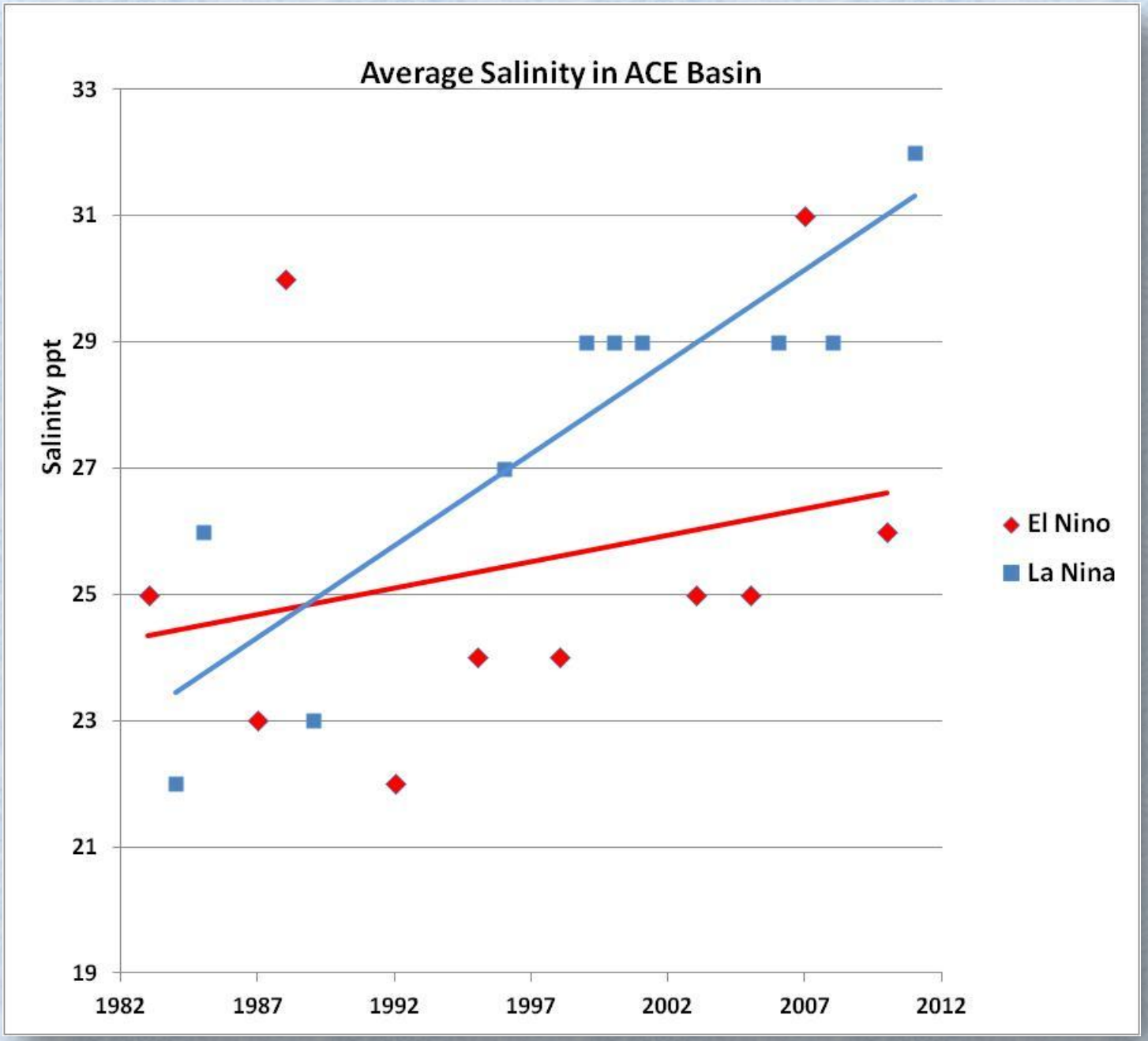


Average March-April River Discharge Shown as Percentage of Long-term Mean and Brown Shrimp Landings




Average Salinity at ACE Basin Shrimp Sampling Stations
Salinity ppt
35
33
31
29
27
25
23
21
19
17
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010


Salinity in Ace Basin, Strong ENSO Years Only
La Nina
El Nino
ACE BASIN
Salinity ppt
35
33
31
29
27
25
23
21
19
17
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010


Average Salinity in ACE Basin
Salinity ppt
33
31
29
27
25
23
21
19
1982
1987
1992
1997
2002
2007
2012
El Nino
La Nina

Conclusions

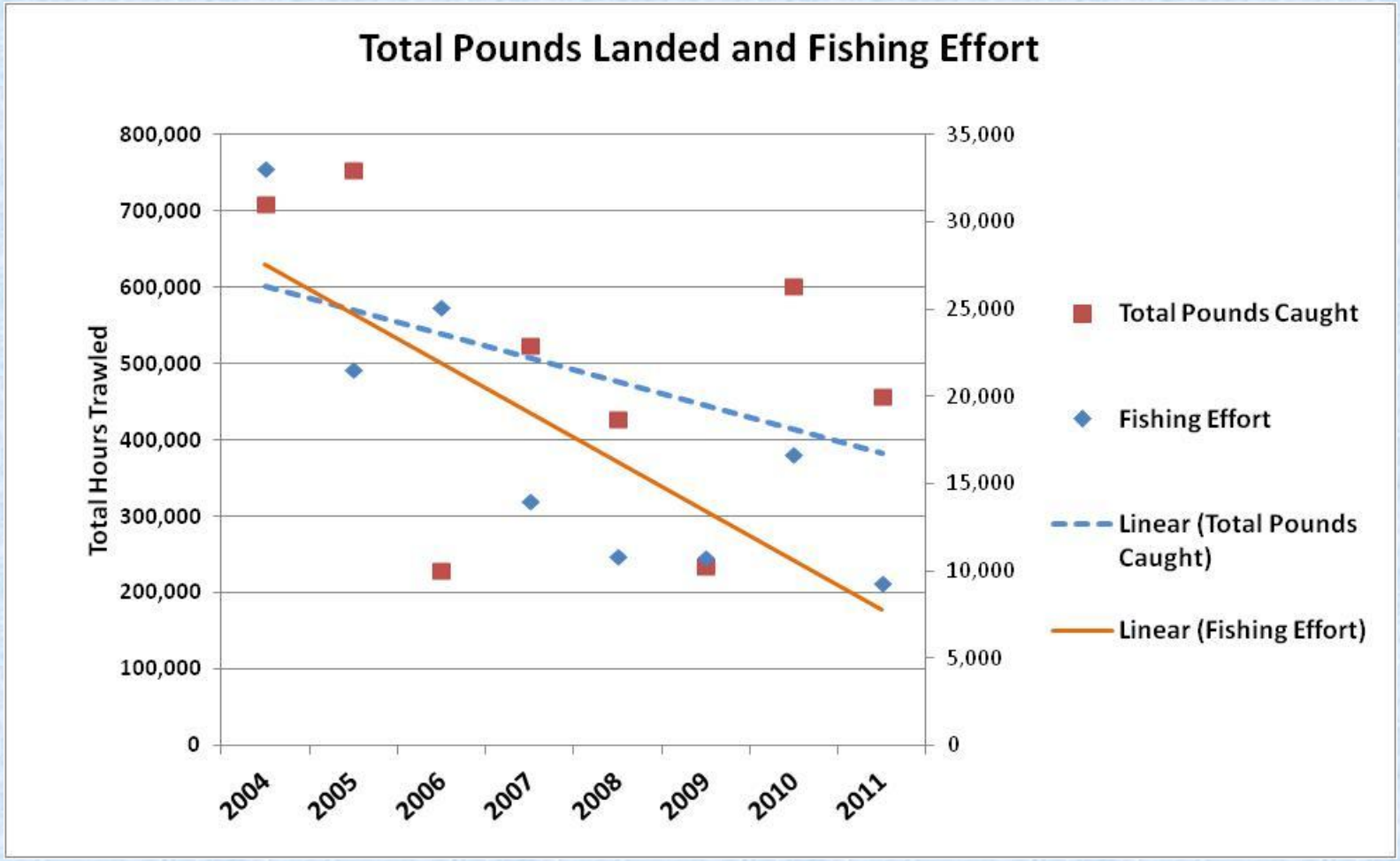
- The frequency of colder-than-normal winters has been reduced in the last two decades resulting in increases in white shrimp spawning populations.

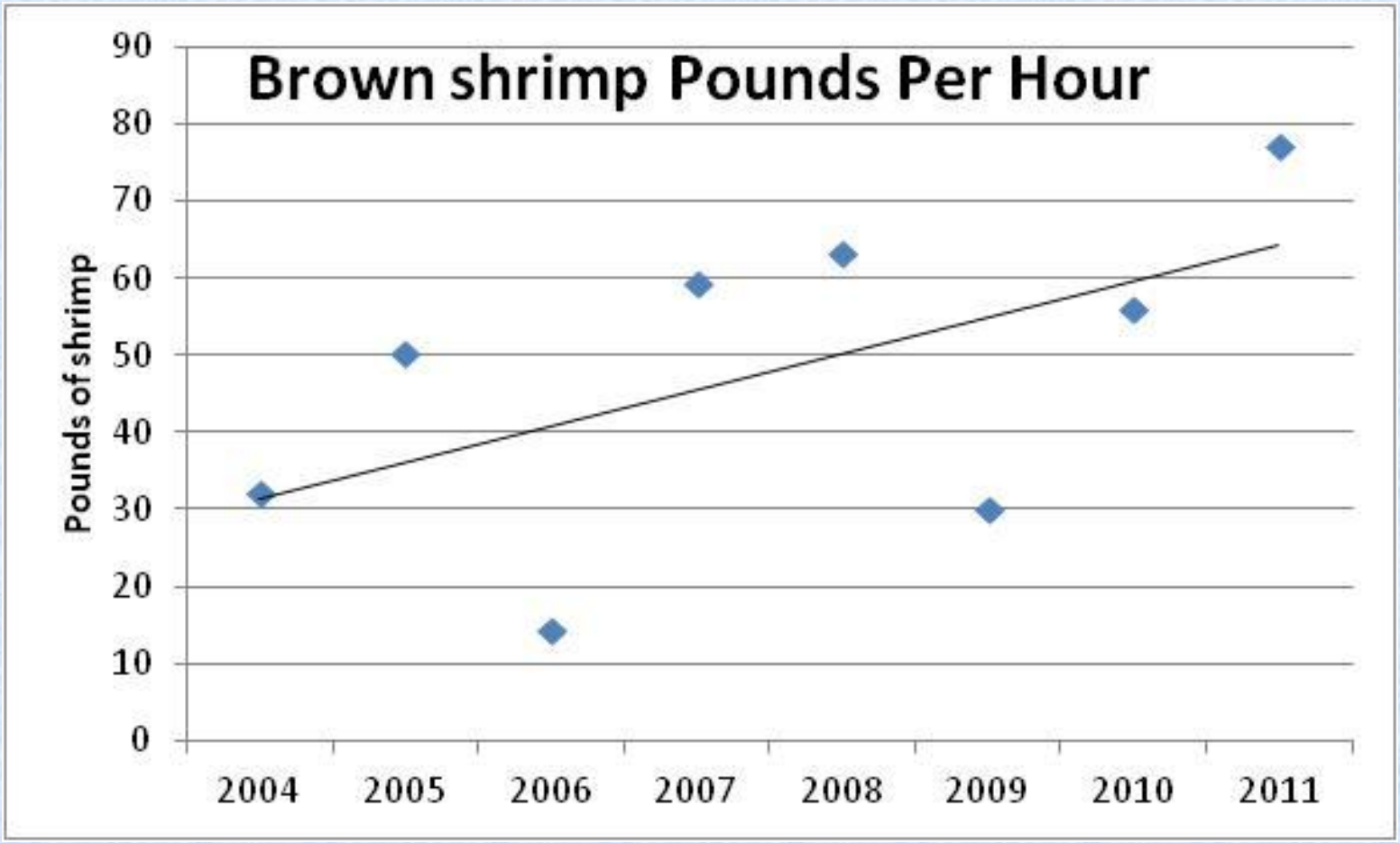
Conclusions

- The frequency of colder-than-normal winters has been reduced in the last two decades resulting in increases in white shrimp spawning populations.
- Warm-than-normal winters over the last decade may be related to reductions in recruitment rates of postlarval brown shrimp.

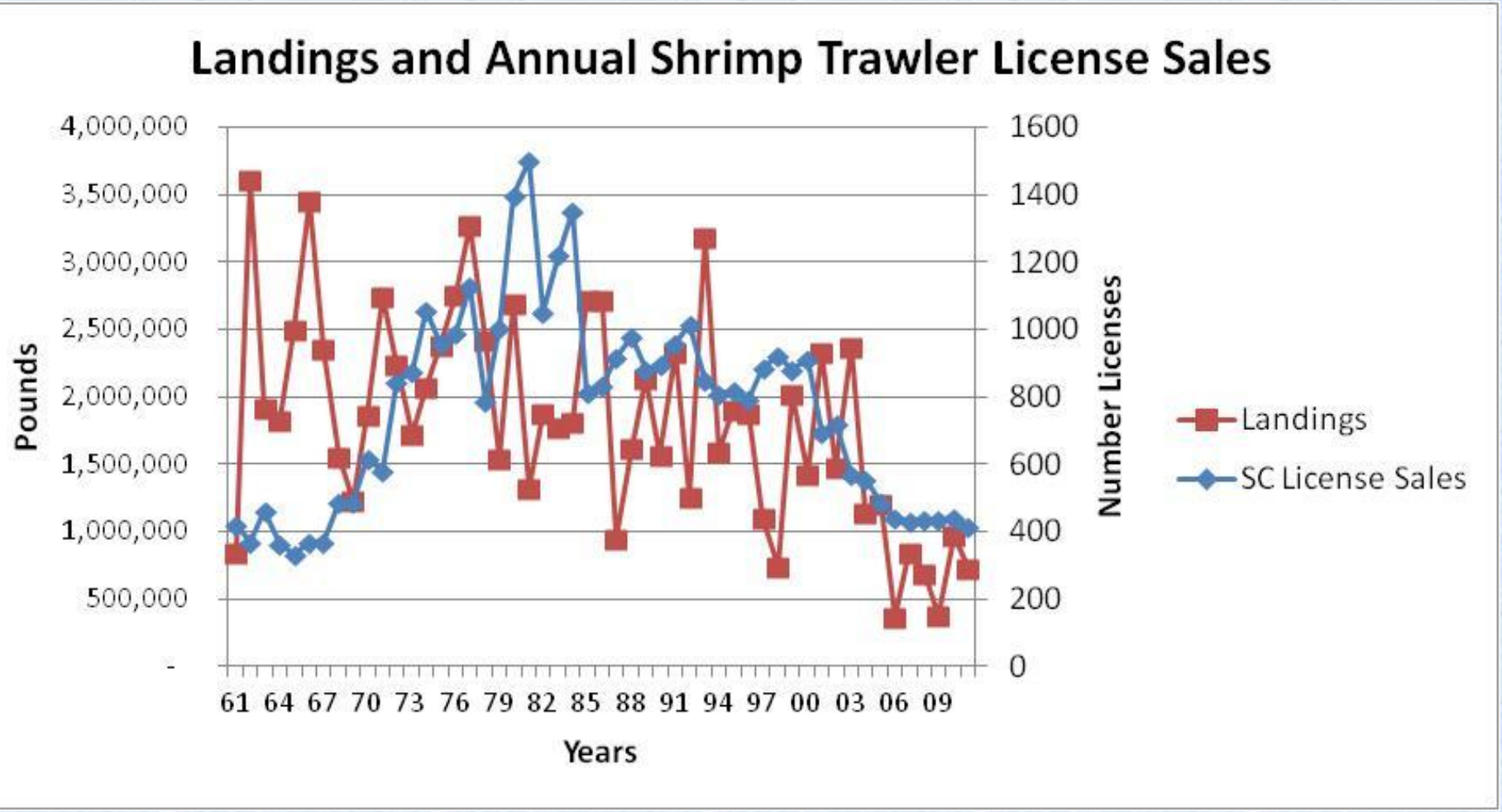
Conclusions

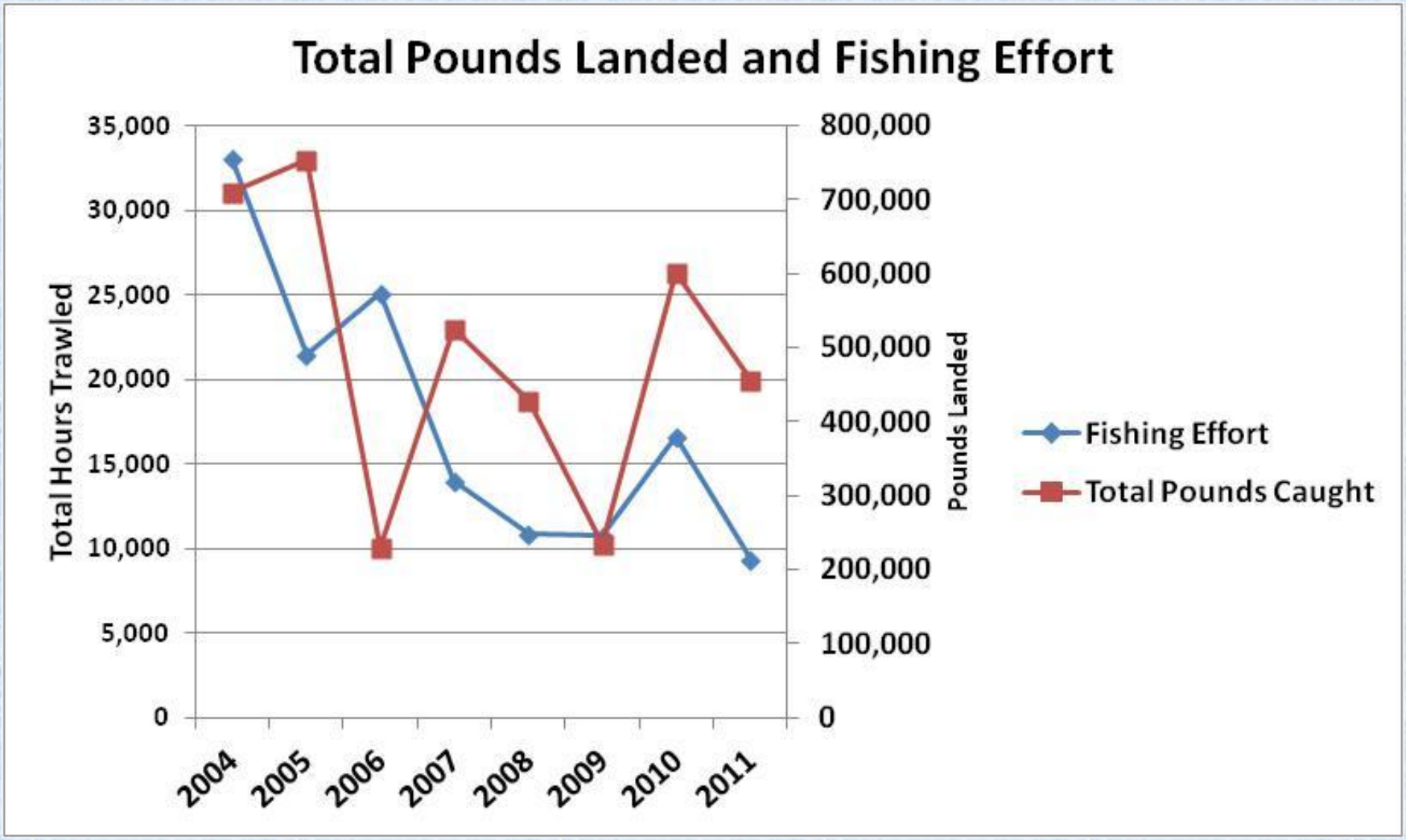
- The frequency of colder-than-normal winters has been reduced in the last two decades resulting in increases in white shrimp spawning populations.
- Warm-than-normal winters over the last decade may be related to reductions in recruitment rates of postlarval brown shrimp.
- Reduced rainfall and river discharge over the last two decades is resulting in increased salinities in coastal estuaries, which may be negatively affecting shrimp physiology and reducing the area of optimal nursery habitat.

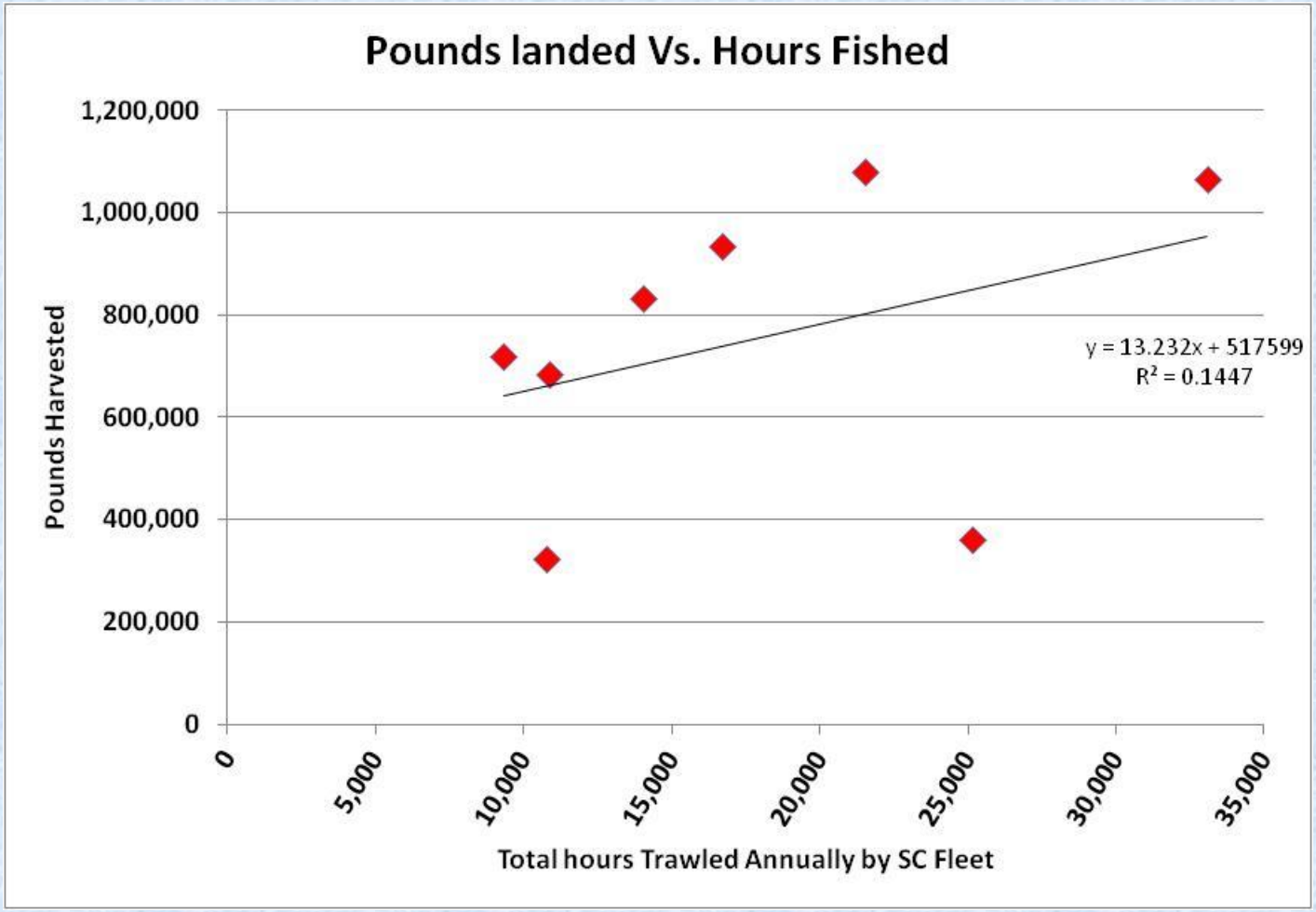

Total Pounds Landed and Fishing Effort
Total Hours Trawled
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
2004
2005
2006
2007
2008
2009
2010
2011
Total Pounds Caught
Fishing Effort
Linear (Total Pounds Caught)
Linear (Fishing Effort)

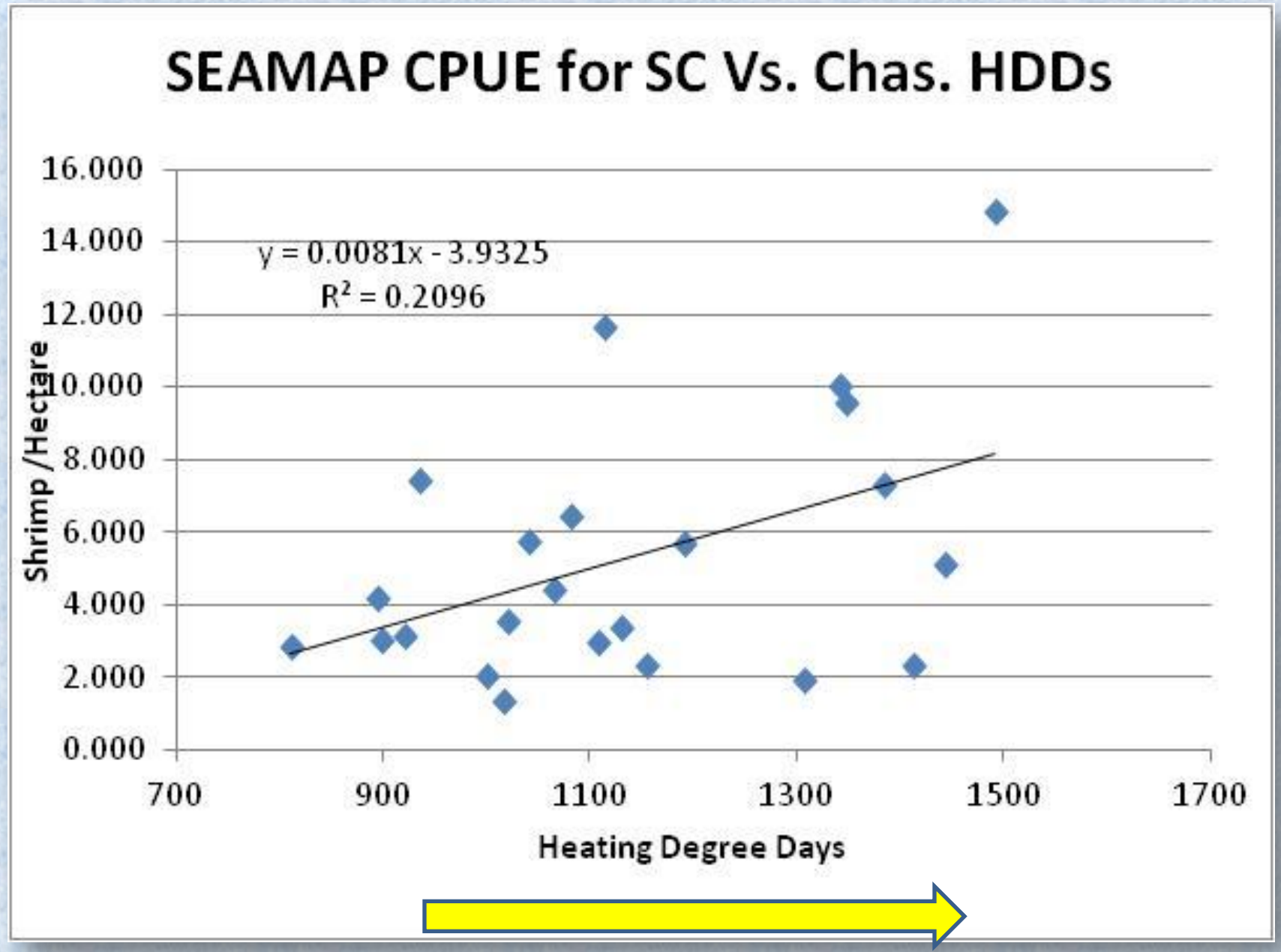


Commercial CPUE is going up despite a general decline in total catch, perhaps somewhat compensating for the overall decline in the total number of trawlers.


Landings and Annual Shrimp Trawler License Sales
Pounds
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
-
Number Licenses
1600
1400
1200
1000
800
600
400
200
0
61 64 67 70 73 76 79 82 85 88 91 94 97 00 03 06 09
Years
Landings
SC License Sales


Total Pounds Landed and Fishing Effort
Total Hours Trawled
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Pounds Landed
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
2004
2005
2006
2007
2008
2009
2010
2011
Fishing Effort
Total Pounds Caught


Pounds landed Vs. Hours Fished
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
Pounds Harvested
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
Total hours Trawled Annually by SC Fleet
y = 13.232x + 517599
R² = 0.1447



Colder Winters