REGIME SHIFT, NPGO, PDO, AND THE SOUTHERN CALIFORNIA KELP FORESTS: THE EFFECT OF CLIMATE VARIABILITY ON COASTAL RESOURCES, 1967-2007

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MBC

Introduction

- North Pacific Gyre Oscillation (NPGO)
- Pacific Decadal Oscillation (PDO)
- 1977 Regime Shift
- Giant Kelp
  - Annual Maximum Aerial Canopy (1967-2007)
    - Similar Response Across Area?
    - Response to NPGO/PDO?
  - Point Loma Adult Density
    - Represent Aerial Canopy?
    - Relationship to N?
    - Response to NPGO/PDO?

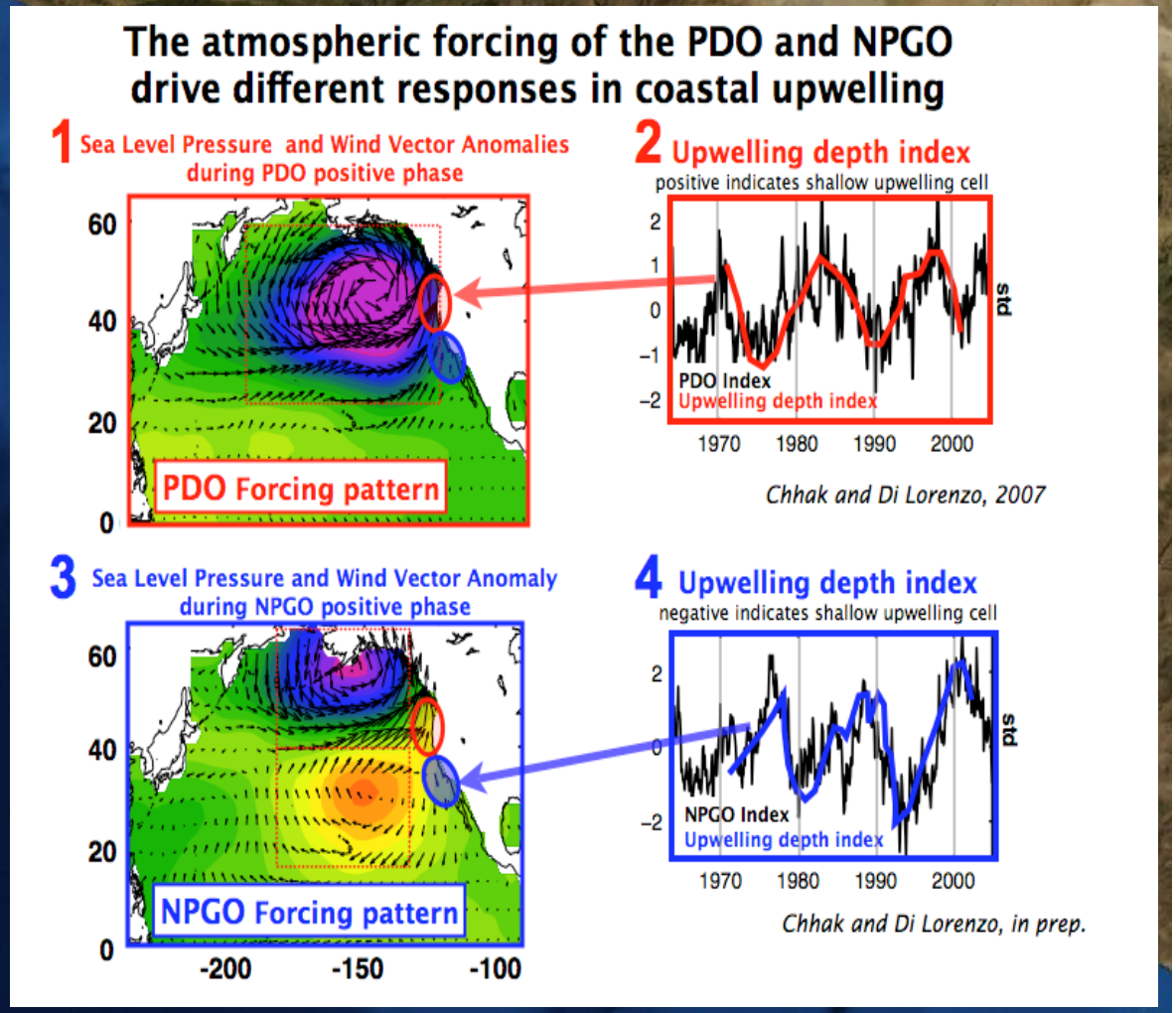
Oceanographic Patterns

-Pacific Decadal Oscillation (PDO)

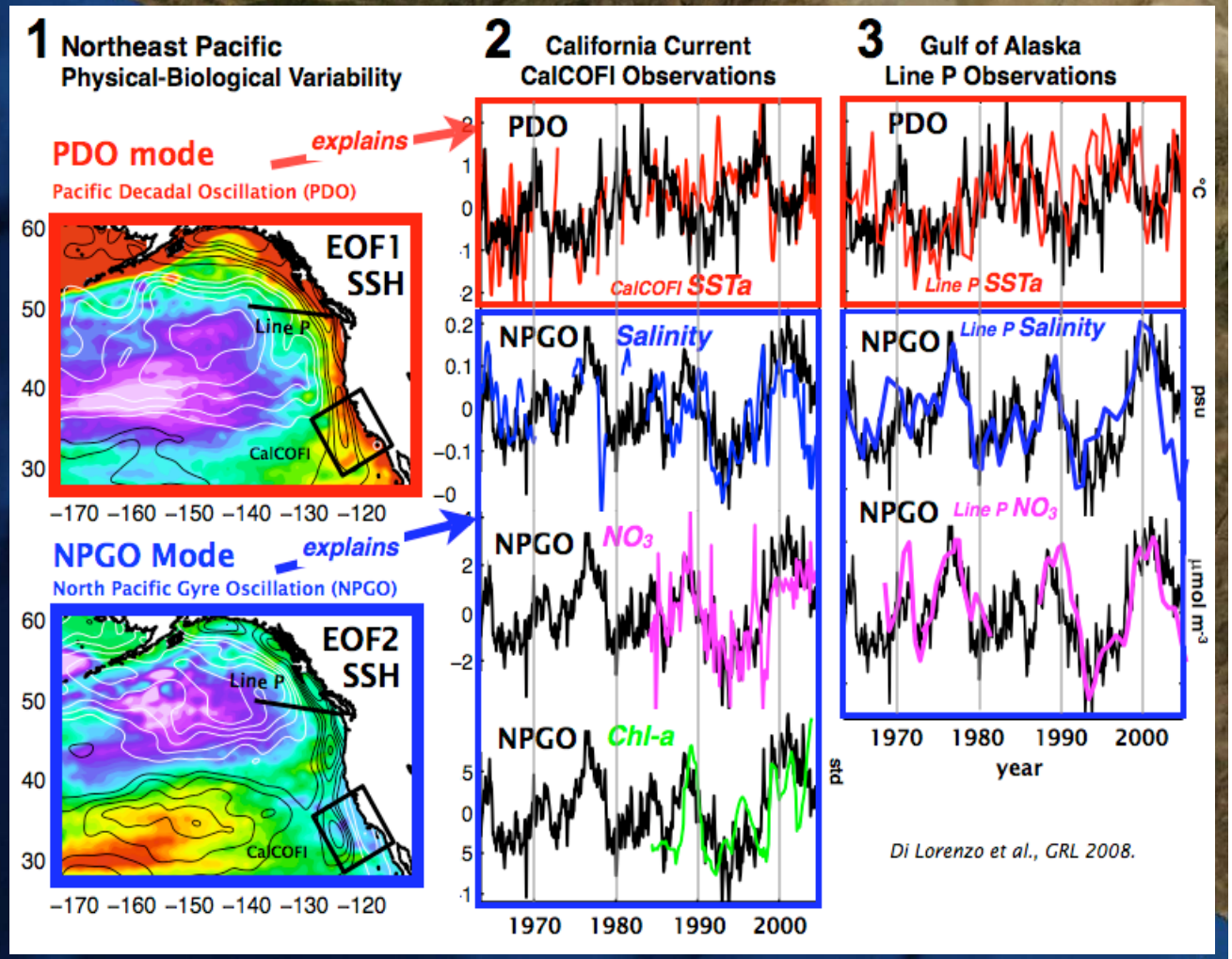
- -Strongest effect north of at least 38°N Latitude

-North Pacific Gyre Oscillation (NPGO)

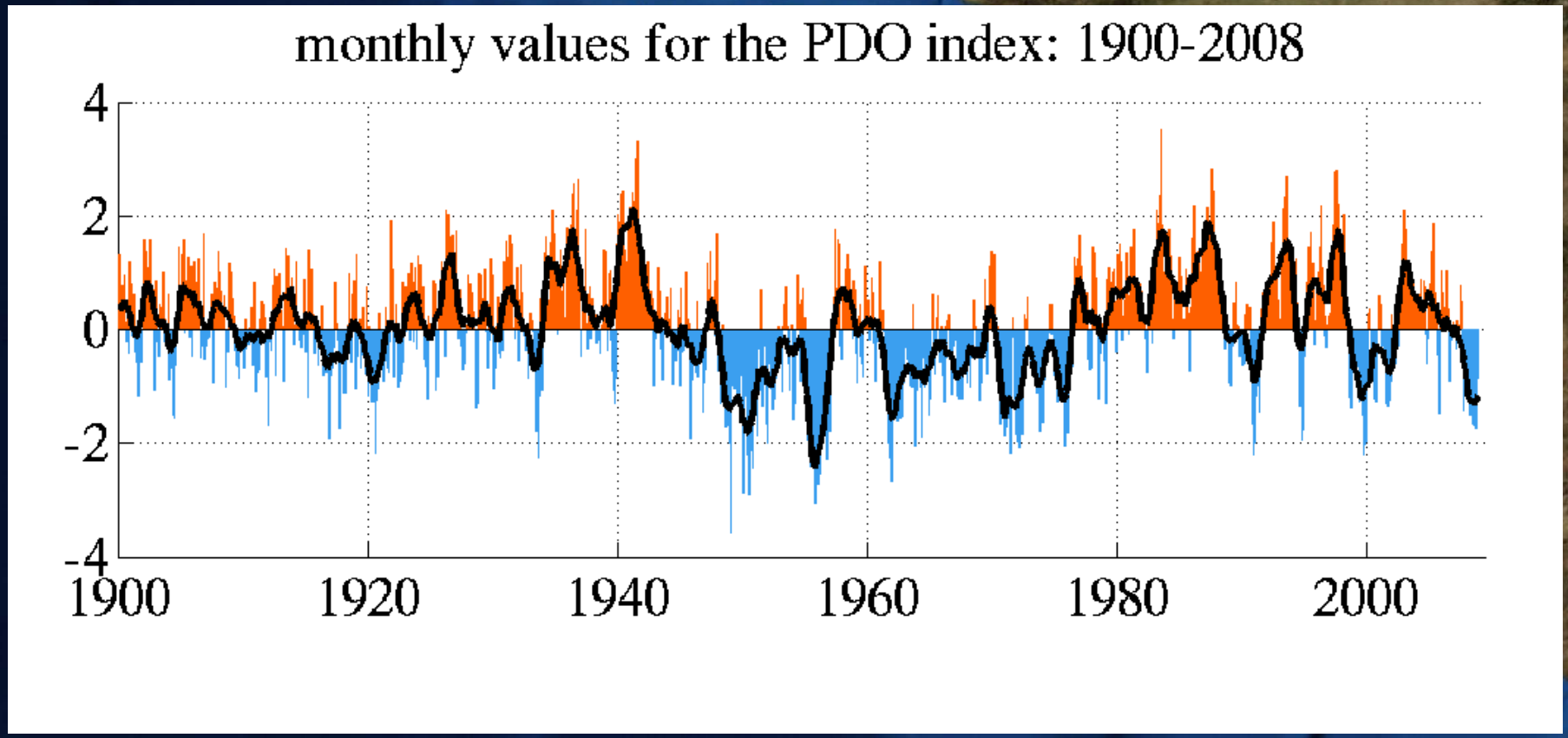
- -Strongest effect south of at least 38°N Latitude



- Basic Requirements for Kelp Growth
  - Light
  - Nutrients
    - Primarily Nitrogen
  - Suitable Substrate
- Biological Control
  - Urchin predation
- Rare Events
  - Storm
  - ENSO

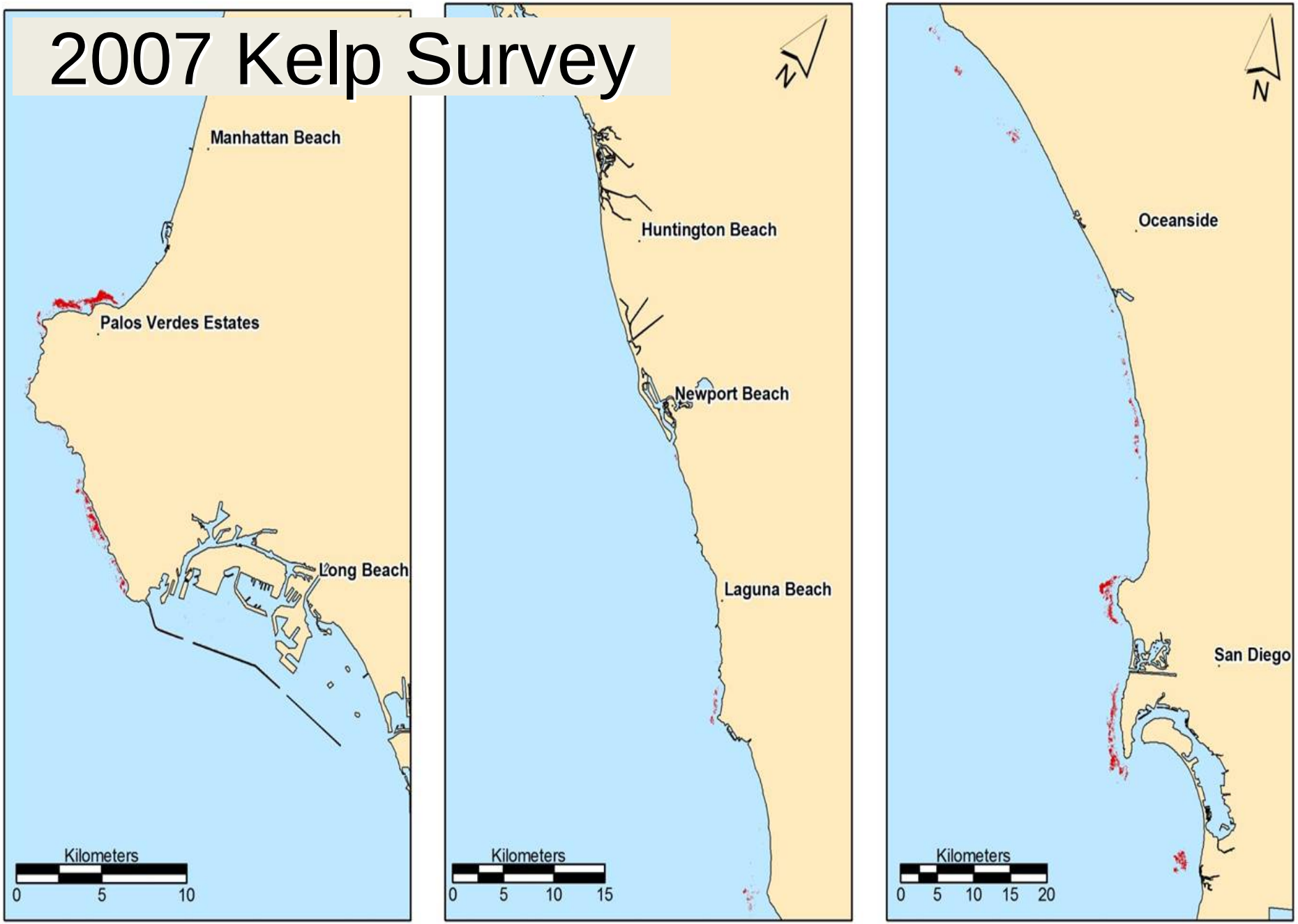


PDO

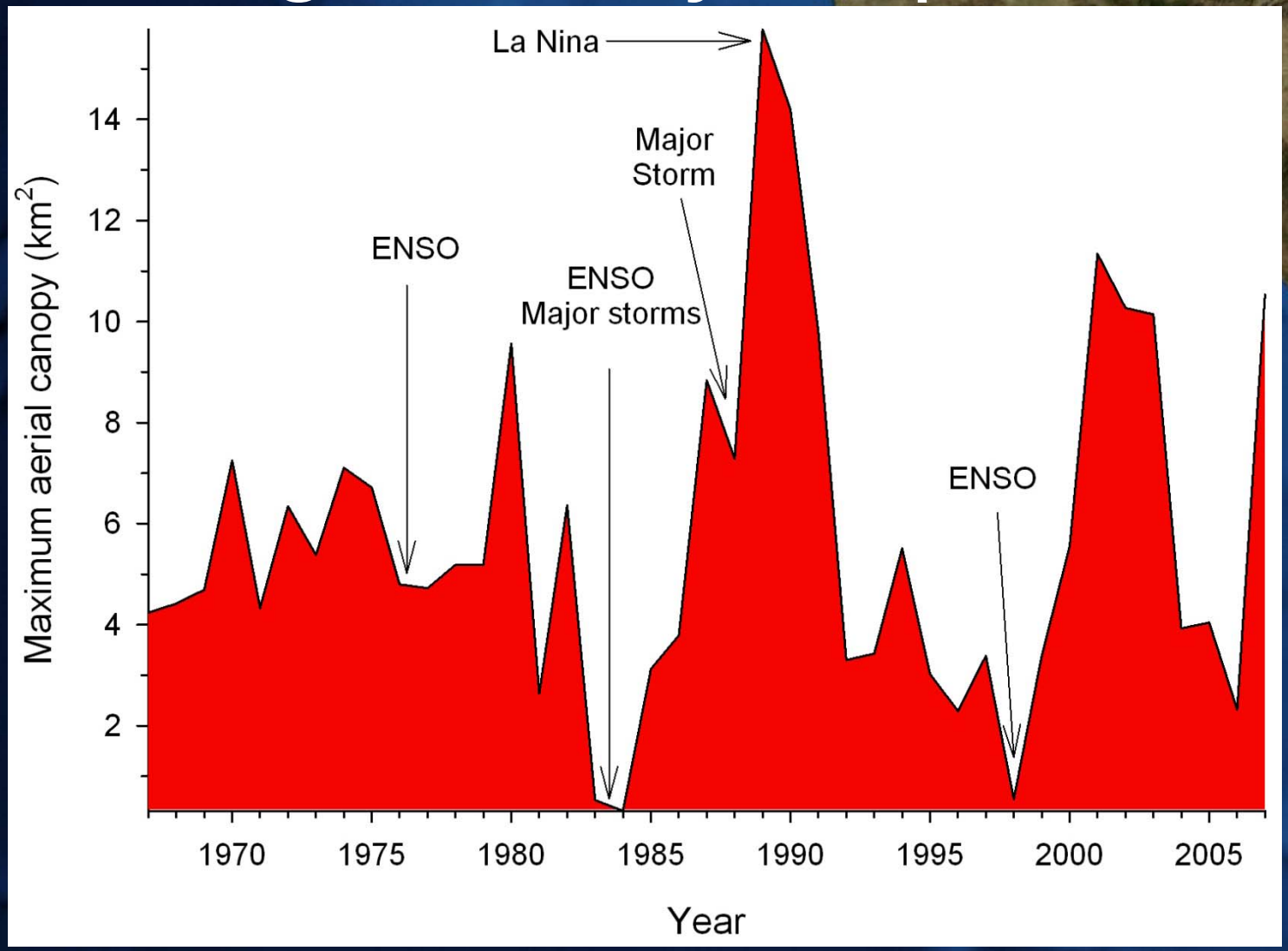


http://jisao.washington.edu/pdo/

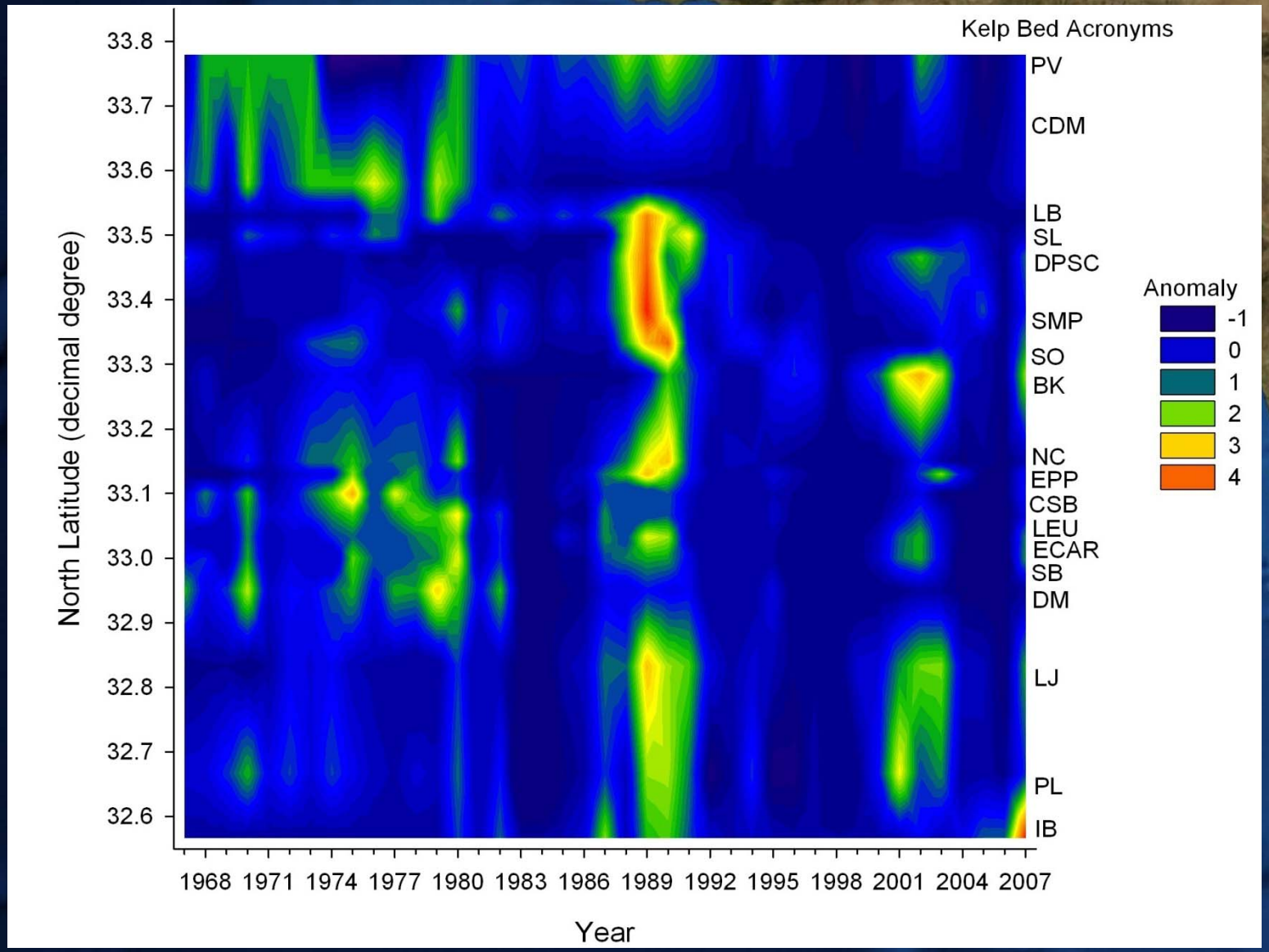
2007 Kelp Survey



Historic Patterns in Orange/San Diego County Kelp Beds



Kelp Bed Anomalies 1967-2007



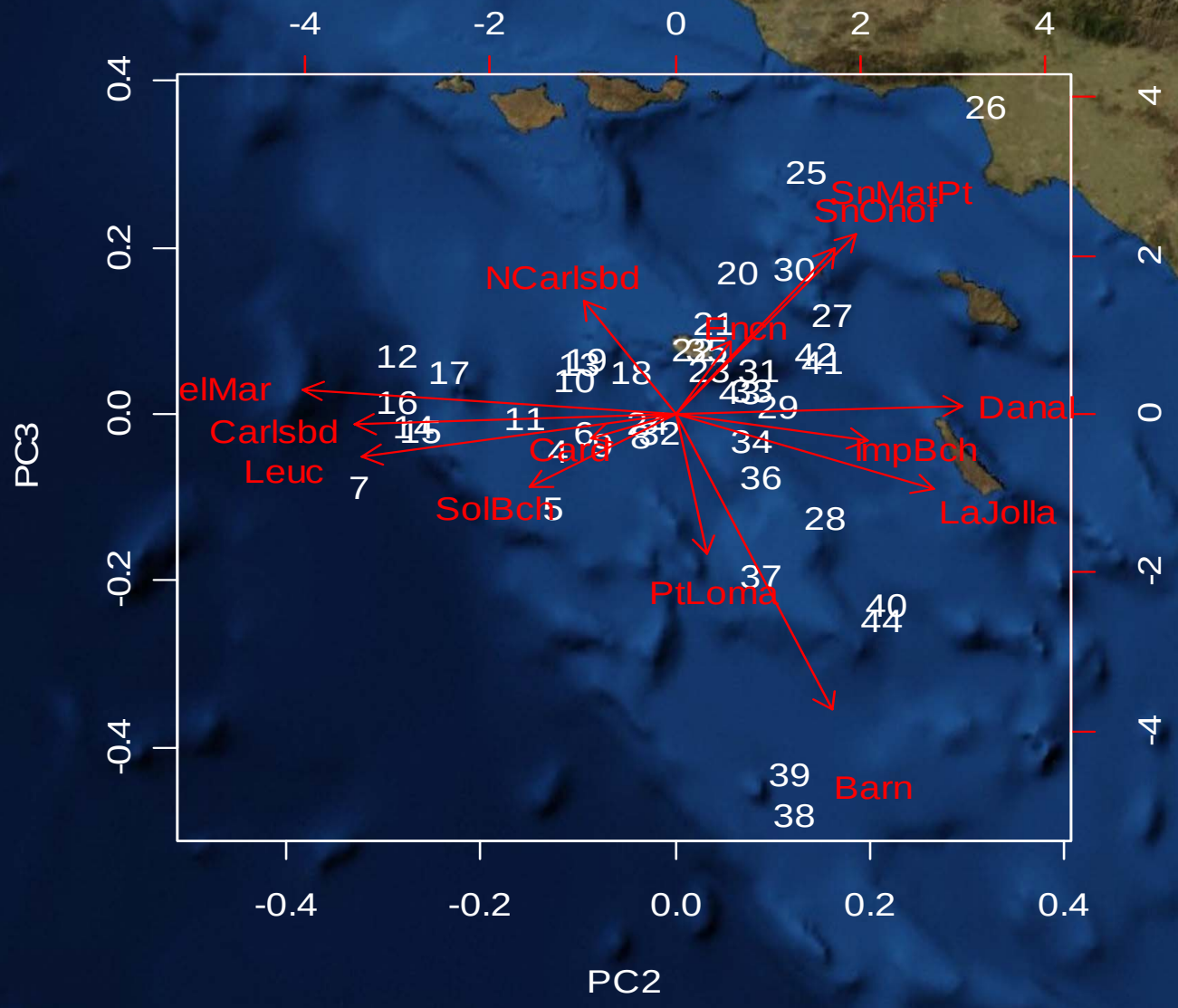
Correlations Between Kelp Beds and Long Term Bed Resiliency

Correlations

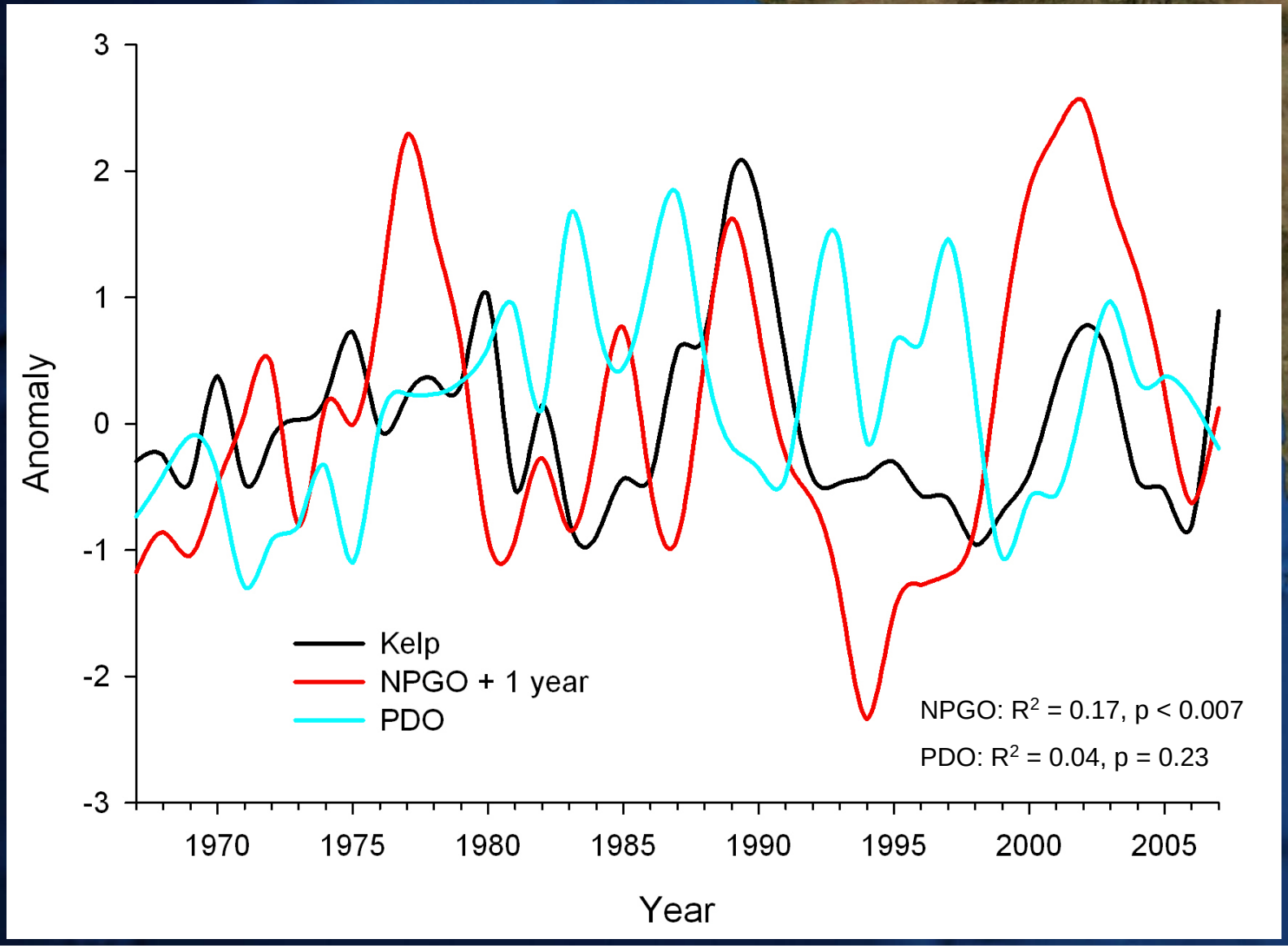
FO	Bed	PV	DPSC	SMP	SO	BK	NC	EPP	CSB	LEU	ECAR	SB	DM	LJ	PL	IB
33	Palos Verdes (PV)	1	**0.52**	**0.52**	**0.45**	0.05	0.26	**0.39**	-0.24	-0.03	0.28	0.19	-0.10	**0.54**	0.21	**0.35**
40	Dana Point/Salt Creek (DPSC)		1	**0.70**	**0.55**	**0.41**	**0.39**	**0.62**	-0.06	0.02	**0.43**	**0.37**	-0.11	**0.82**	**0.50**	**0.39**
38	San Mateo Point (SMP)			1	**0.76**	0.12	**0.65**	**0.73**	0.07	0.25	**0.64**	**0.49**	0.10	**0.68**	**0.43**	**0.45**
35	San Onofre (SO)				1	0.22	**0.72**	**0.70**	0.23	0.21	**0.54**	**0.36**	0.07	**0.63**	**0.45**	**0.45**
31	Barn Kelp (BK)					1	0.16	**0.36**	0.11	0.17	**0.38**	**0.35**	-0.14	**0.62**	**0.49**	0.29
36	North Carlsbad (NC)						1	**0.77**	**0.66**	**0.70**	**0.80**	**0.70**	**0.51**	**0.54**	**0.58**	0.23
34	Encina Power Plant (EPP)							1	**0.47**	**0.52**	**0.73**	**0.62**	0.27	**0.71**	**0.50**	**0.34**
34	Carlsbad State Beach (CSB)								1	**0.82**	**0.58**	**0.62**	**0.69**	0.06	**0.34**	0.03
40	Leucadia (LEU)									1	**0.79**	**0.83**	**0.83**	0.22	**0.50**	0.11
39	Encinitas/Cardiff (ECAR										1	**0.88**	**0.57**	**0.61**	**0.69**	**0.41**
41	Solana Beach (SB)											1	**0.64**	**0.50**	**0.66**	**0.34**
33	Del Mar (DM)												1	-0.07	**0.33**	-0.07
41	La Jolla (LJ)													1	**0.71**	**0.55**
41	Point Loma (PL)														1	**0.35**
25	Imperial Beach (IB)															1

Bold = Correlation significant at the $p < 0.05$ level (two-tailed).

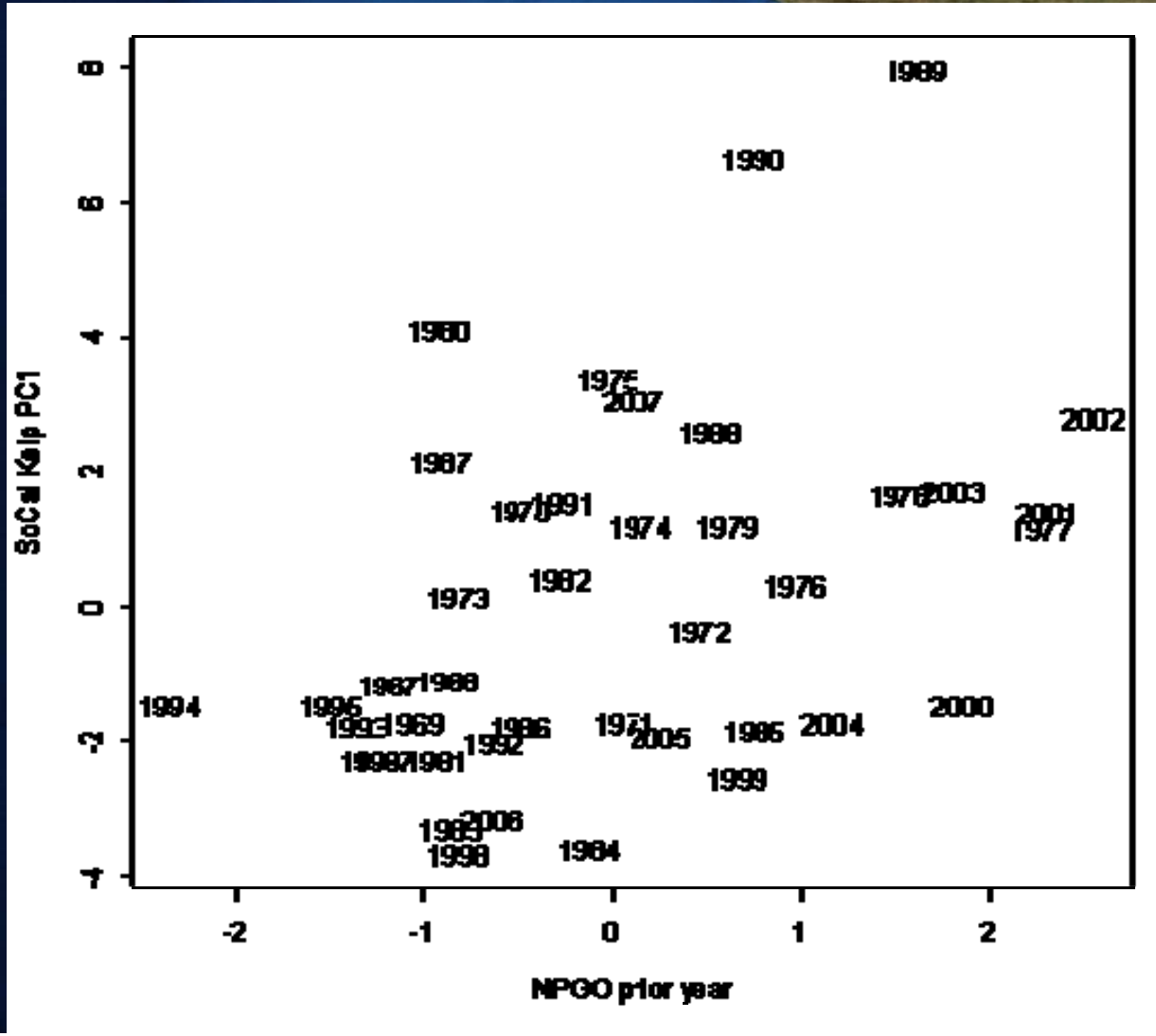
PCA of Maximum Canopy by Site



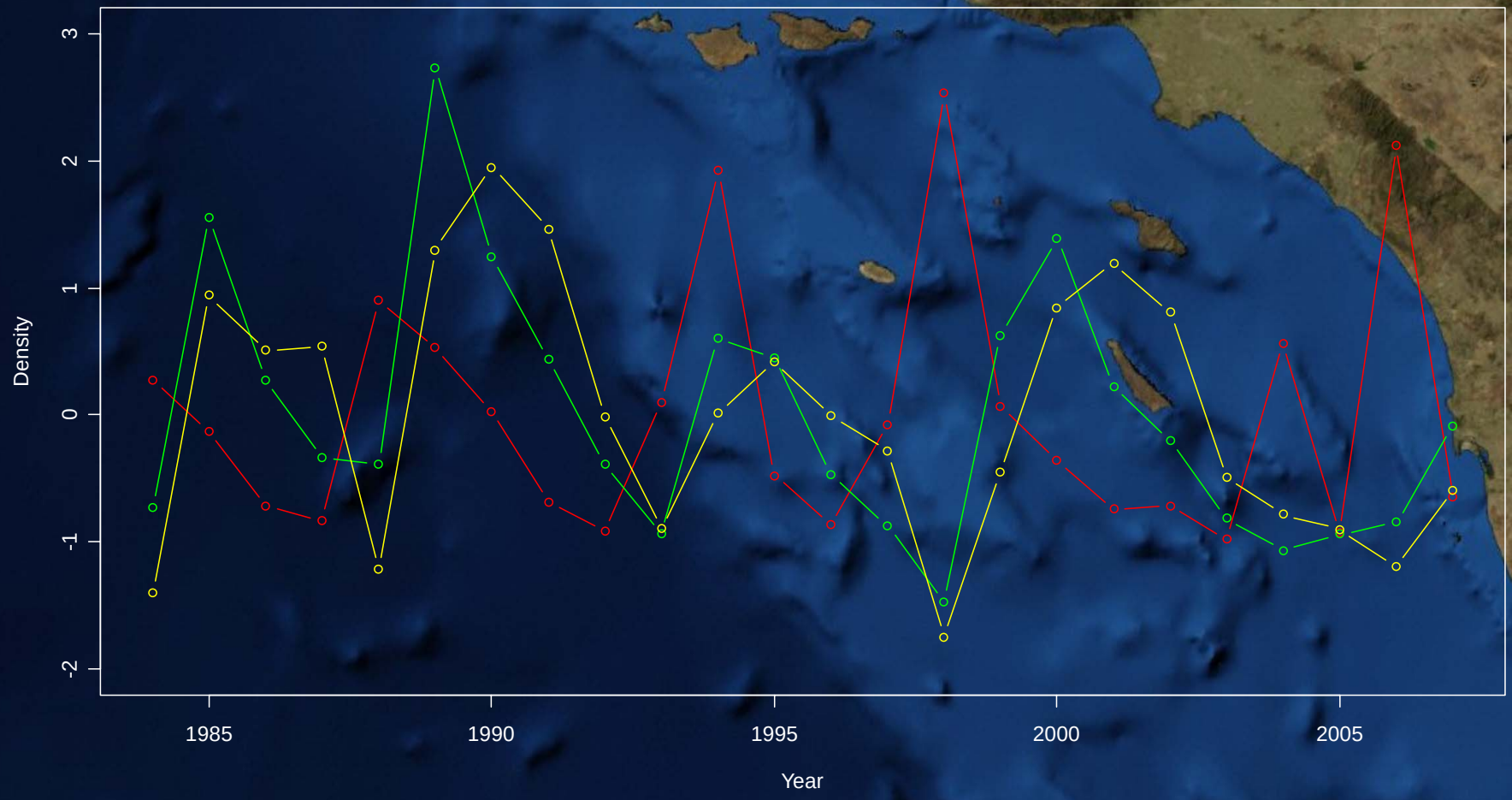
Maximum Kelp Bed Aerial Canopy Anomaly and PDO/NPGO



PCA Kelp and NPGO Lagged 1 Year

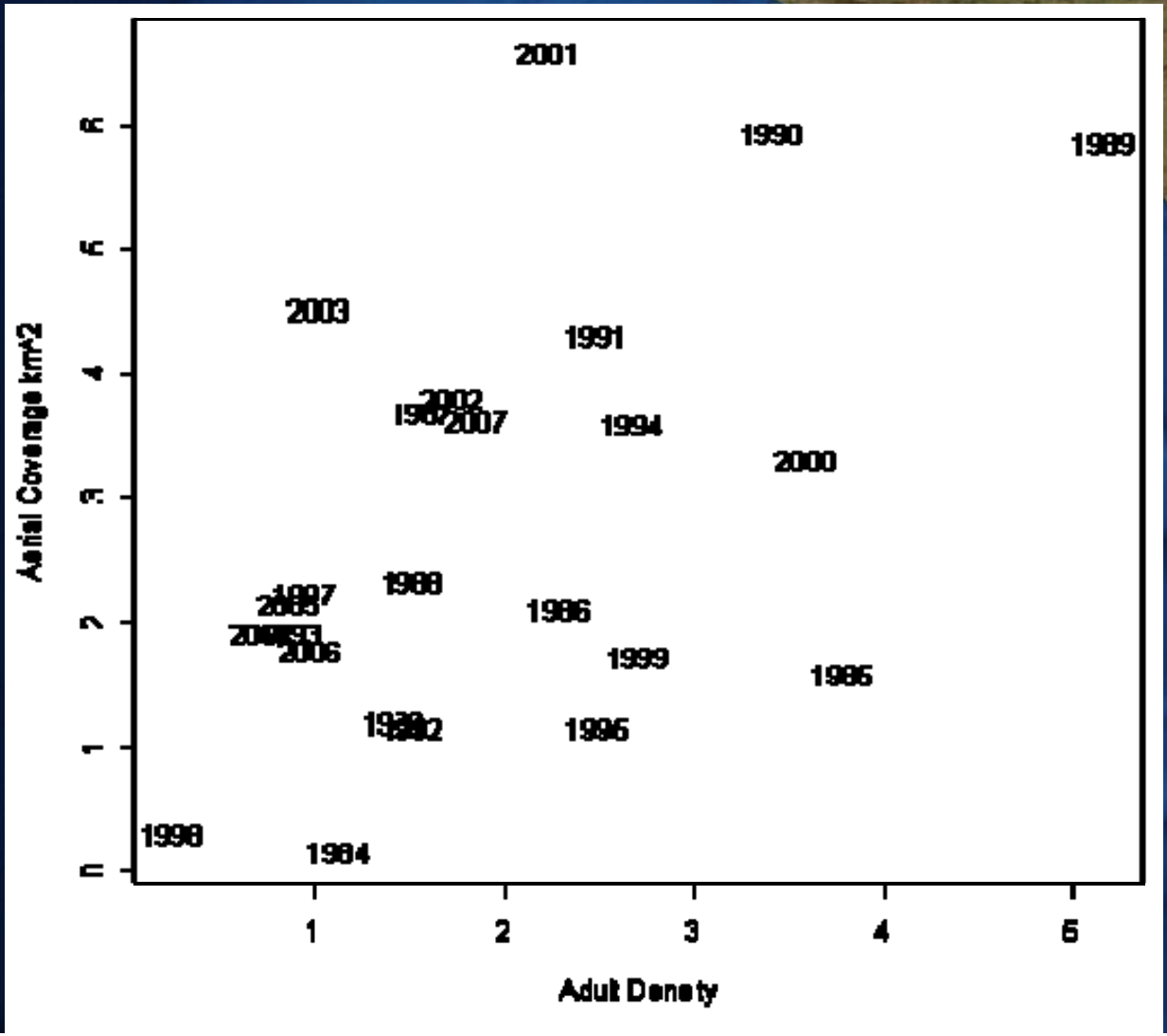


Kelp Density at Point Loma by Life Stage



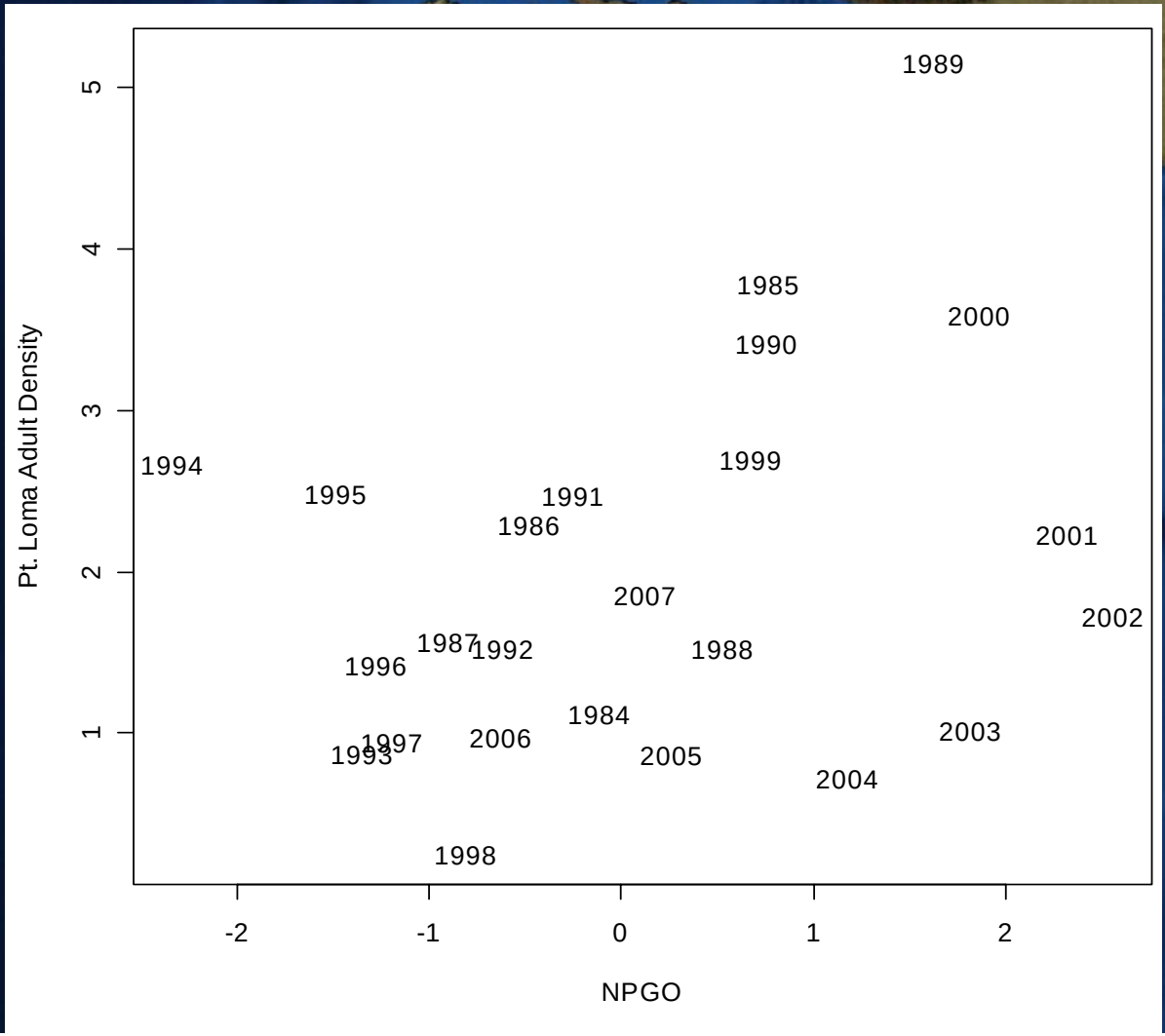
Recruit, Adult, Stipe

Pt. Loma Adult Density and Aerial Canopy



$R^2 = 0.26$

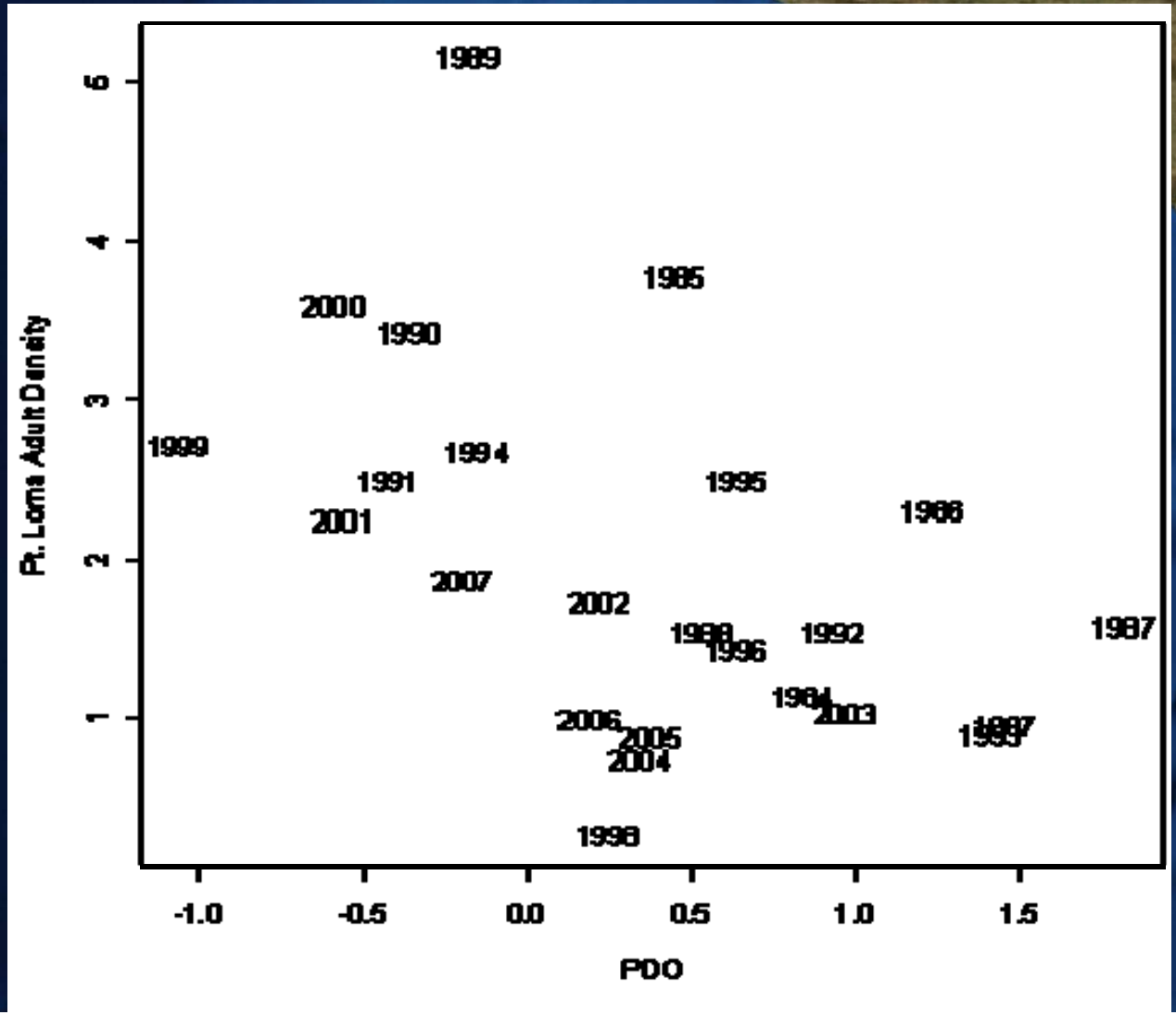
Pt. Loma Adult Density and NPGO Lagged One Year



r = 0.32

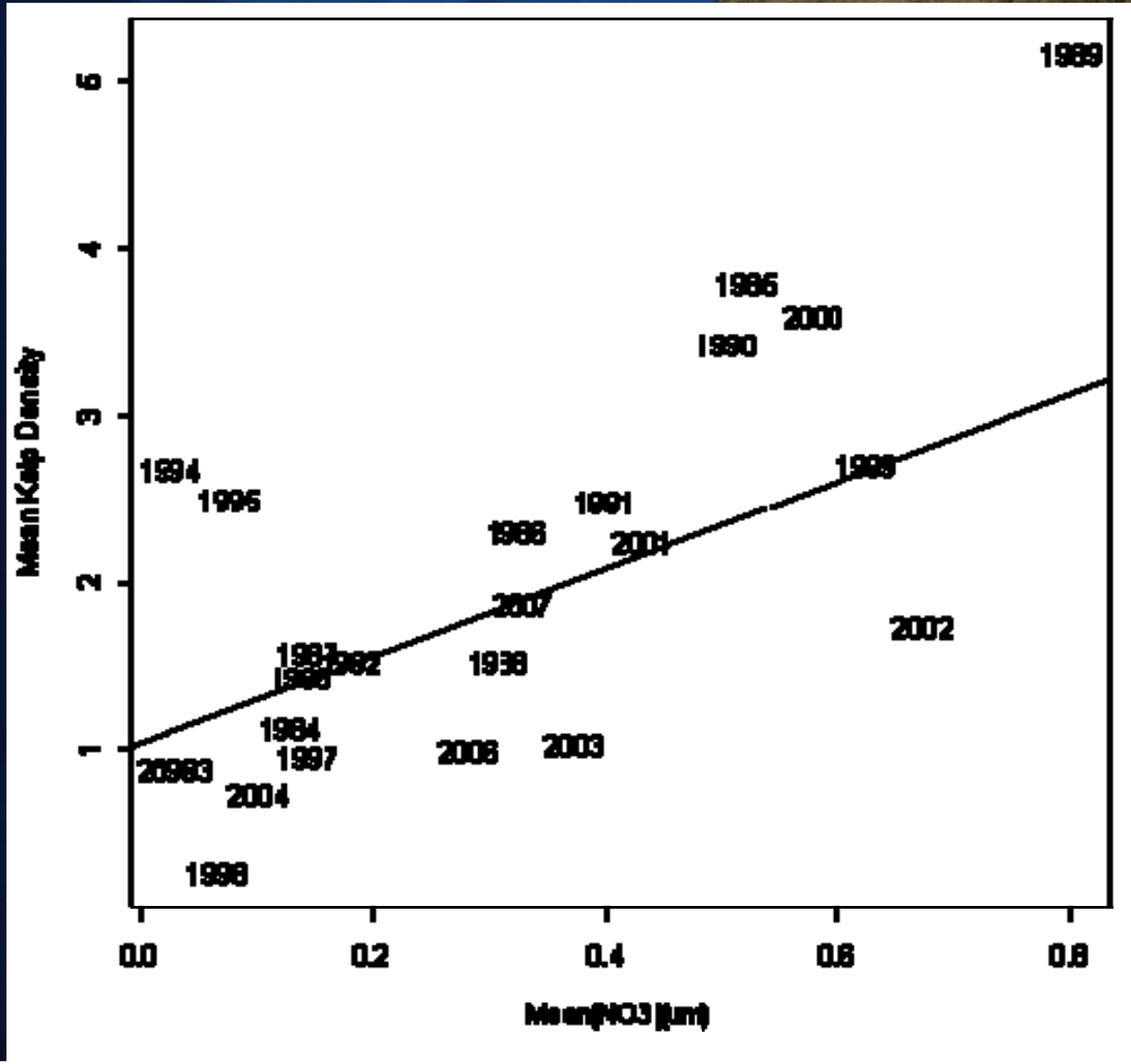
R^2 = 0.10

Pt. Loma Adult Density and PDO



r = -0.49
R^2 = 0.24

Pt. Loma Adult Density and NO_3



$R^2 = 0.50$

Conclusions

- Significant relationship in annual fluctuation between beds
  - SD Beds better related than OC or LA Beds
  - Break at the San Onofre/San Mateo area
  - Barn Kelp was an outlier

Conclusions

- NPGO better related to Aerial Canopy than PDO
  - Indicative of NPGO relationship with nitrogen
- Anomalous events and urchin predation may reduce relationship
  - Low frequency storms

Conclusions

- Pt. Loma adult density
  - Related to Aerial Canopy
  - PDO better predictor of adult density
    - Temperature and nitrogen relationship
- More instability since 1977 regime shift

Acknowledgements

- Dr. Wheeler North for starting and maintaining the aerial surveys
- Chuck Mitchell and Mike Curtis for continuing surveys
- Members of the Region 9 Kelp Consortium for continued support

Wheeler at Freshman Camp, Catalina, late August, 1977