Spatiotemporal Variation of Benthic Communities Associated with Weathervane Scallop Beds off Alaska

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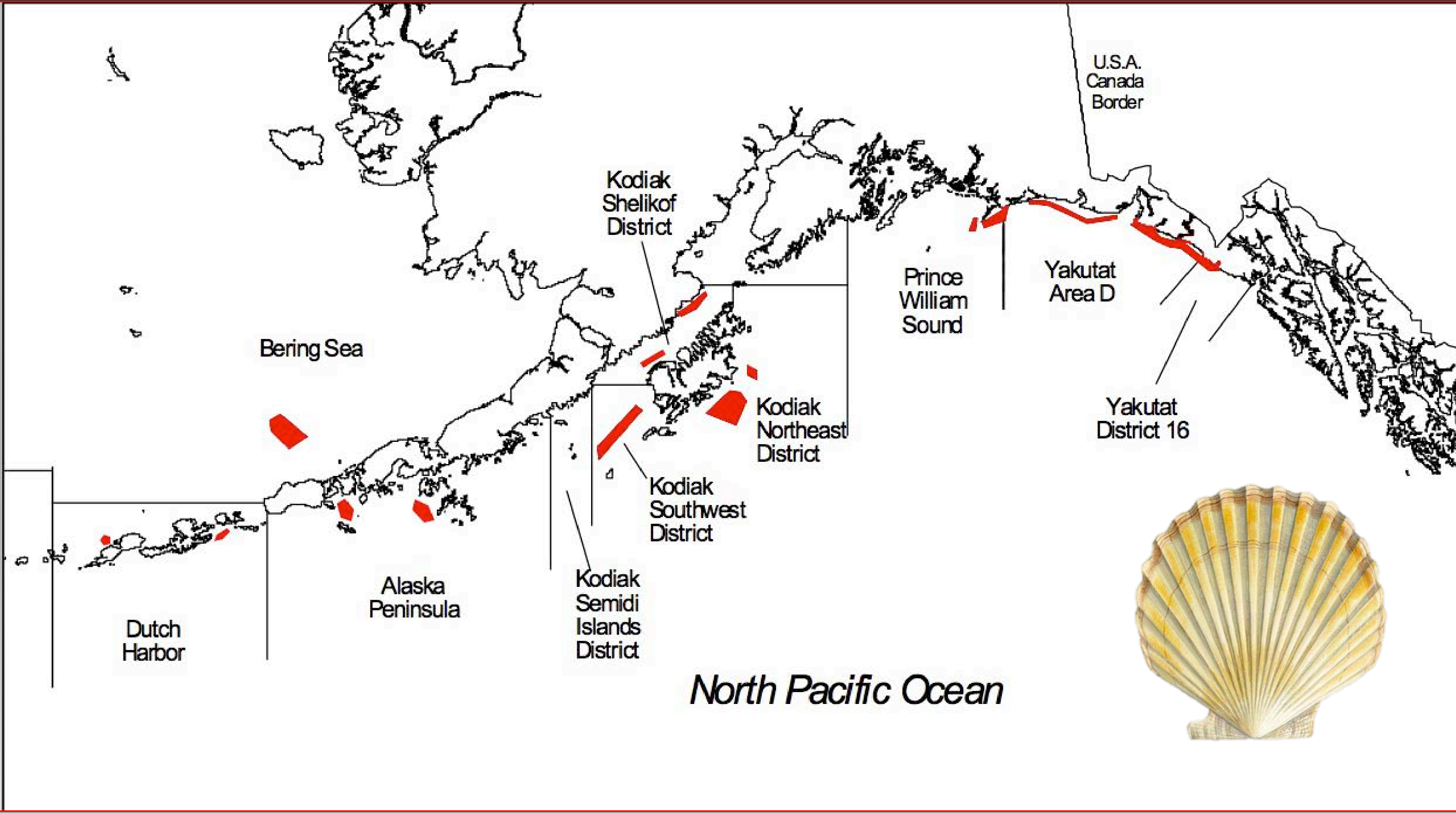
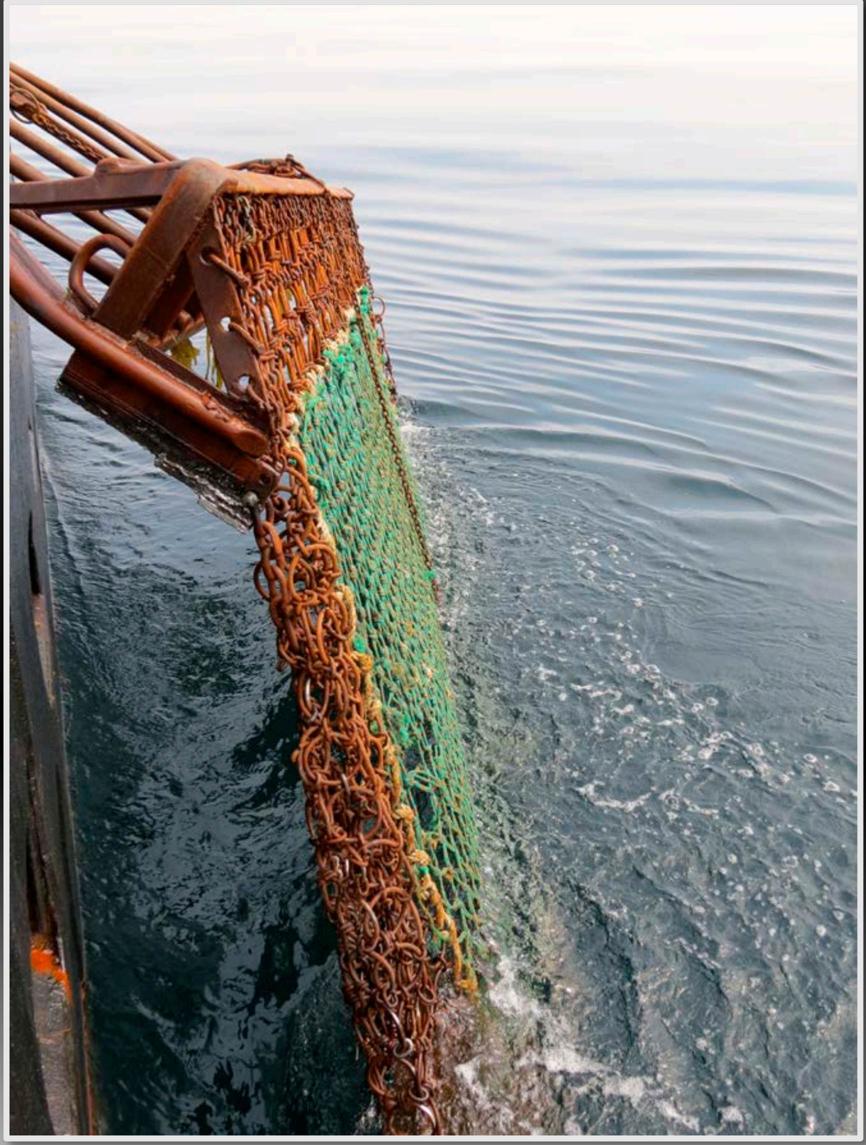
Fishery Distribution for Weathervane Scallops (*Patinopecten caurinus*)



Scallop Dredge Sampling

- Two 4.6 m wide dredges
  - 10 cm diameter rings
- 100% observer coverage
  - 1 haul/day/vessel for species composition



Fishery Bycatch

Study Objectives

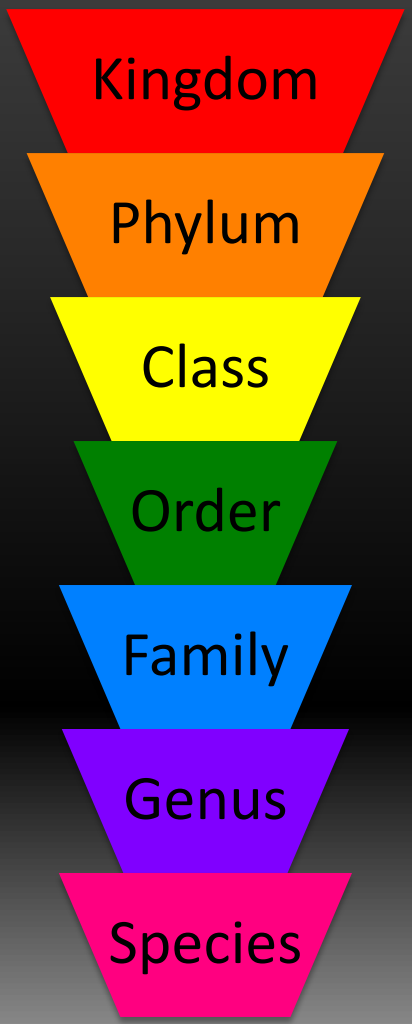
1) Quantify spatial distribution of benthic species on scallop beds

2) Quantify changes over time

3) Relate to environmental & anthropogenic variables

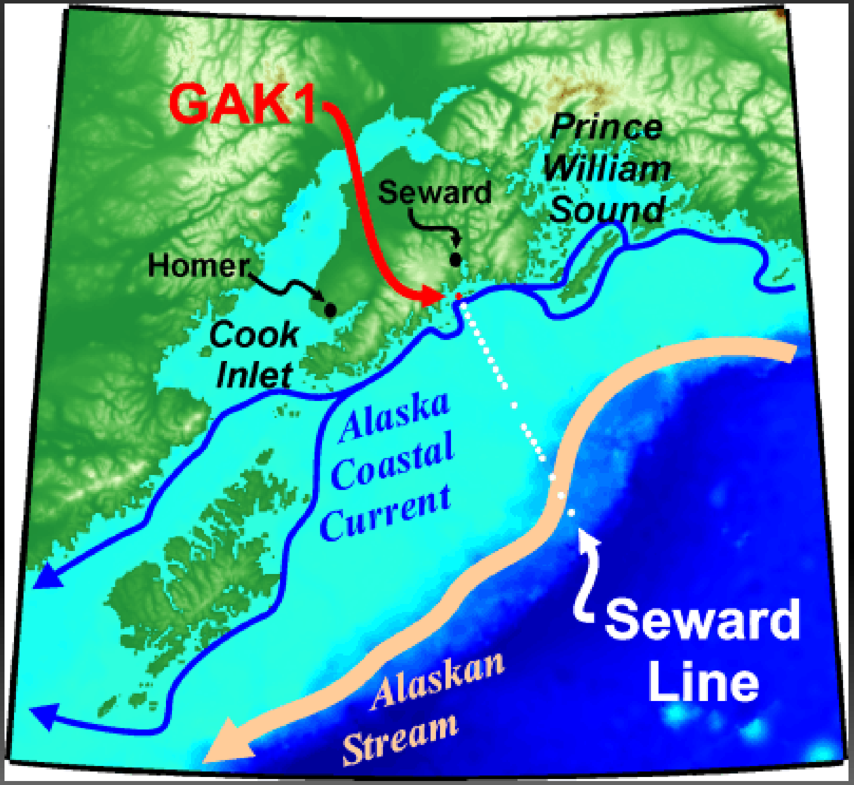
Observer Data (ADF&G)

- Catch per unit effort (kg/m^2)
- 1996-2012
- 4,420 hauls
  - 10 registration districts
  - 42 individual scallop beds
- 300 taxa → 79 taxa



Environmental Variables

- Depth
  - Vessel logbooks (ADF&G)
- Surface sediments
  - Bering Sea & Aleut. Is. (NMFS)
  - Gulf of Alaska (USGS)
- Near-bottom temperature
  - GAK1
  - Bering Sea trawl surveys
- Freshwater input (Royer model)
  - Proxy for surface currents



Anthropogenic Variables

- Trawling effort (NMFS)
  - Catch in Areas database
    - Bottom and pelagic trawls
  - Proportion of bed trawled
- Dredging effort (ADF&G)
  - Proportion of bed dredged

Spatial and Temporal Resolution

- **Spatial**
  - District-scale
    - 1997, 2000, 2010
  - Bed-scale
    - Kodiak Shelikof
    - Kodiak Northeast
    - Yakutat/D16/Prince William Sound
- **Temporal (1996-2012)**
  - Kodiak Shelikof (Bed 1)
  - Kodiak Northeast
  - Yakutat/D16/Prince William Sound
  - Bering Sea

PRIMER

Data preparation

Min. 5% contribution	4^{th} root transformed	Standardized

Non-metric multidimensional scaling

Test significance

Analysis of similarity (ANOSIM)

Identify species responsible

Similarity percentages (SIMPER)

Bio-Environmental analysis (Spearman rank correlation)

Environmental variables	Anthropogenic variables

Visualization of Approach

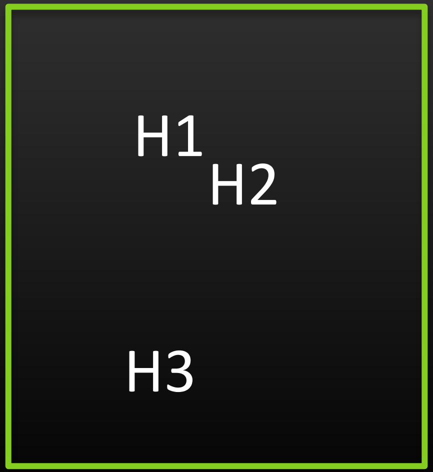
Sampled Hauls

	H1	H2	H3
	0.8	0.7	0.3
	0.01	0.01	0.04
	0.05	0.07	0.06
	0.1	0.2	0.1
	0.01	0.01	0.01

Data: CPUE for each taxa

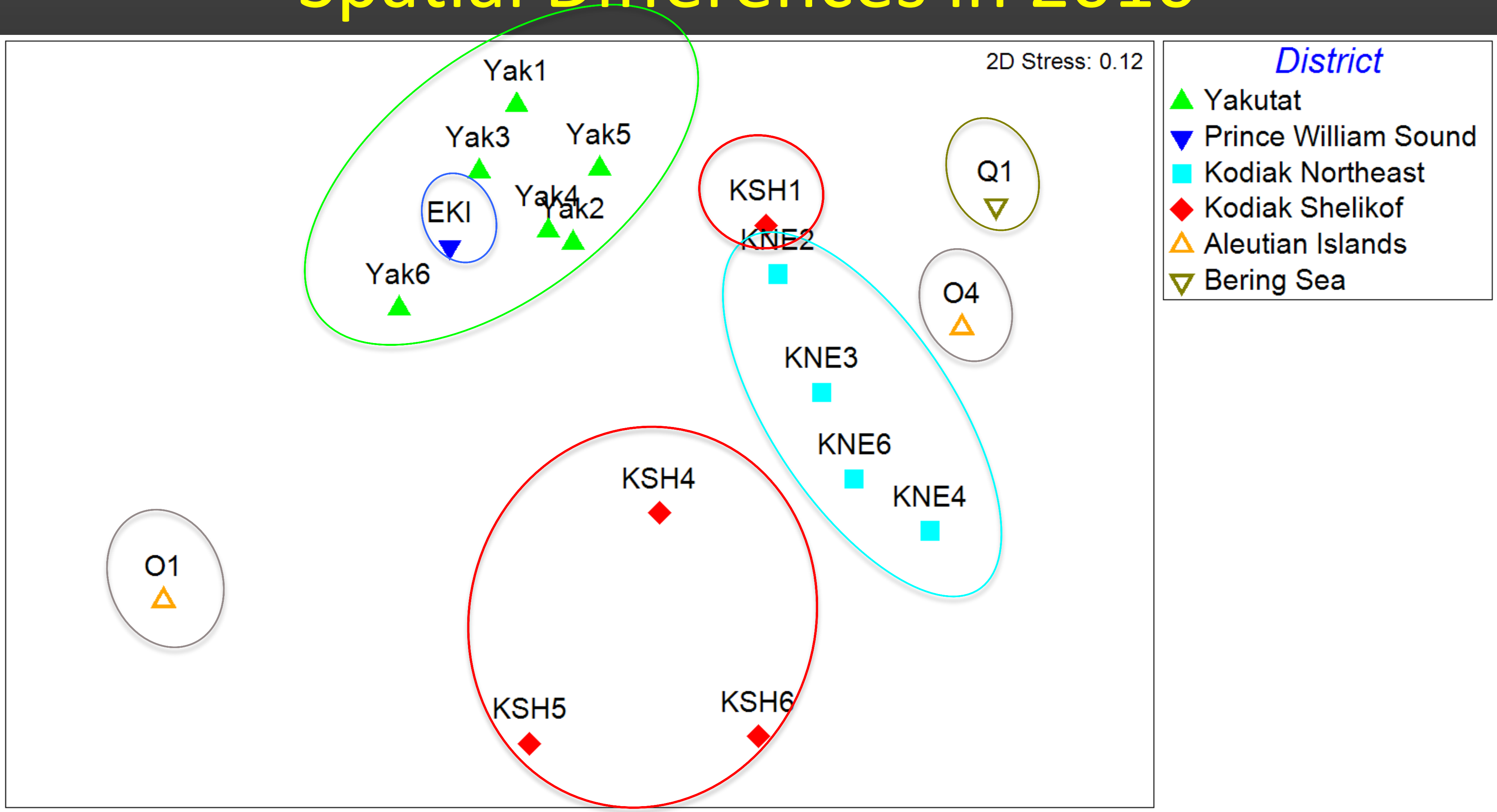
	H1	H2	H3
H1			
H2	0.6		
H3	0.2	0.3	

Similarity matrix



Ordination (NMDS)

NMDS Results: Spatial Differences in 2010



Significant Spatial Differences

- Spatial differences across all districts and between some beds ($P = 0.001$)
  - ANOSIM
    - 1997 (Clarke's R = 0.533)
    - 2000 (Clarke's R = 0.646)
    - 2010 (Clarke's R = 0.682)
  - Largest differences between Yakutat and Aleutian Islands
- Spatial differences tend to be correlated with sediment and depth

Dominant Taxa

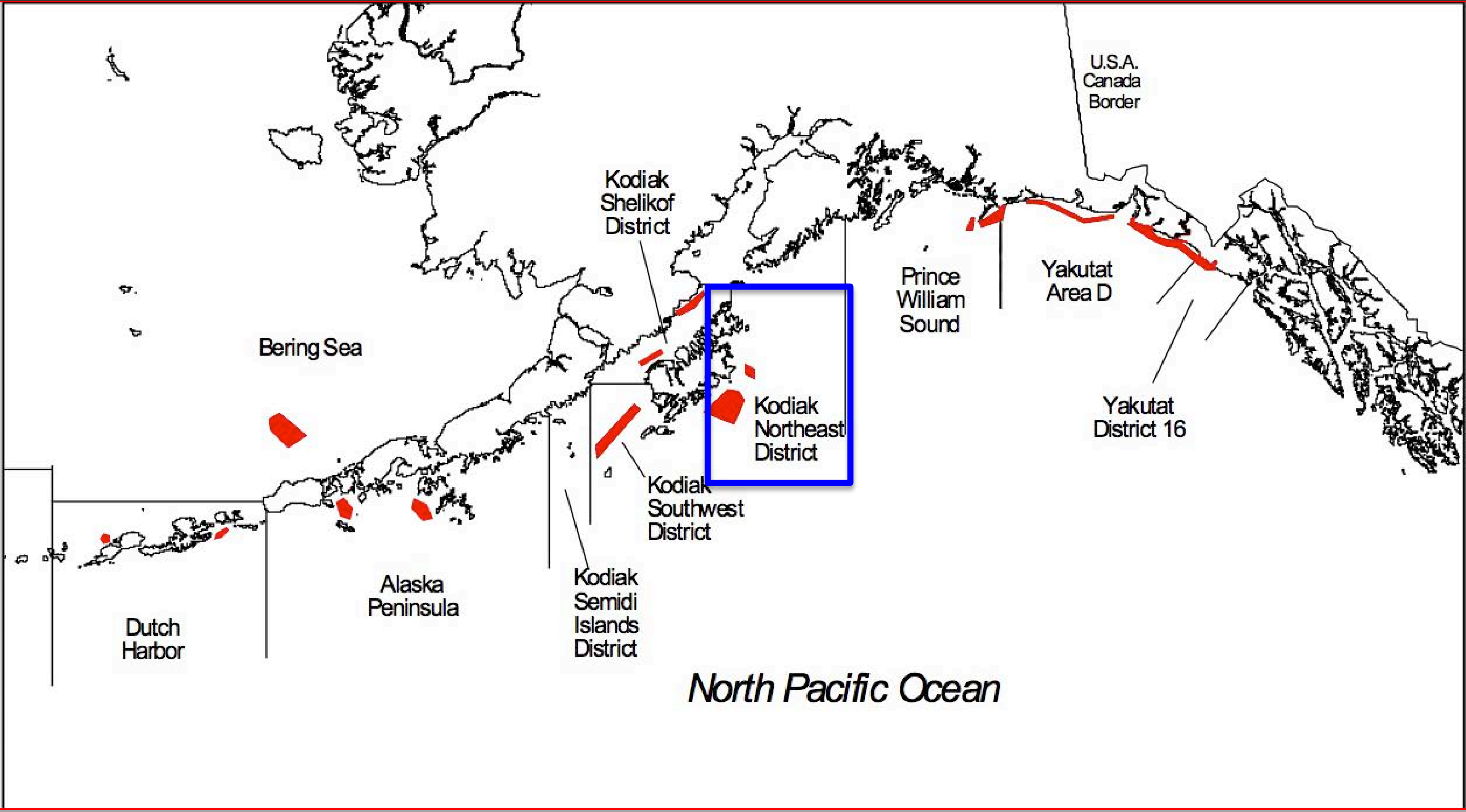
Pectinidae (scallops)

Rajidae (skates)

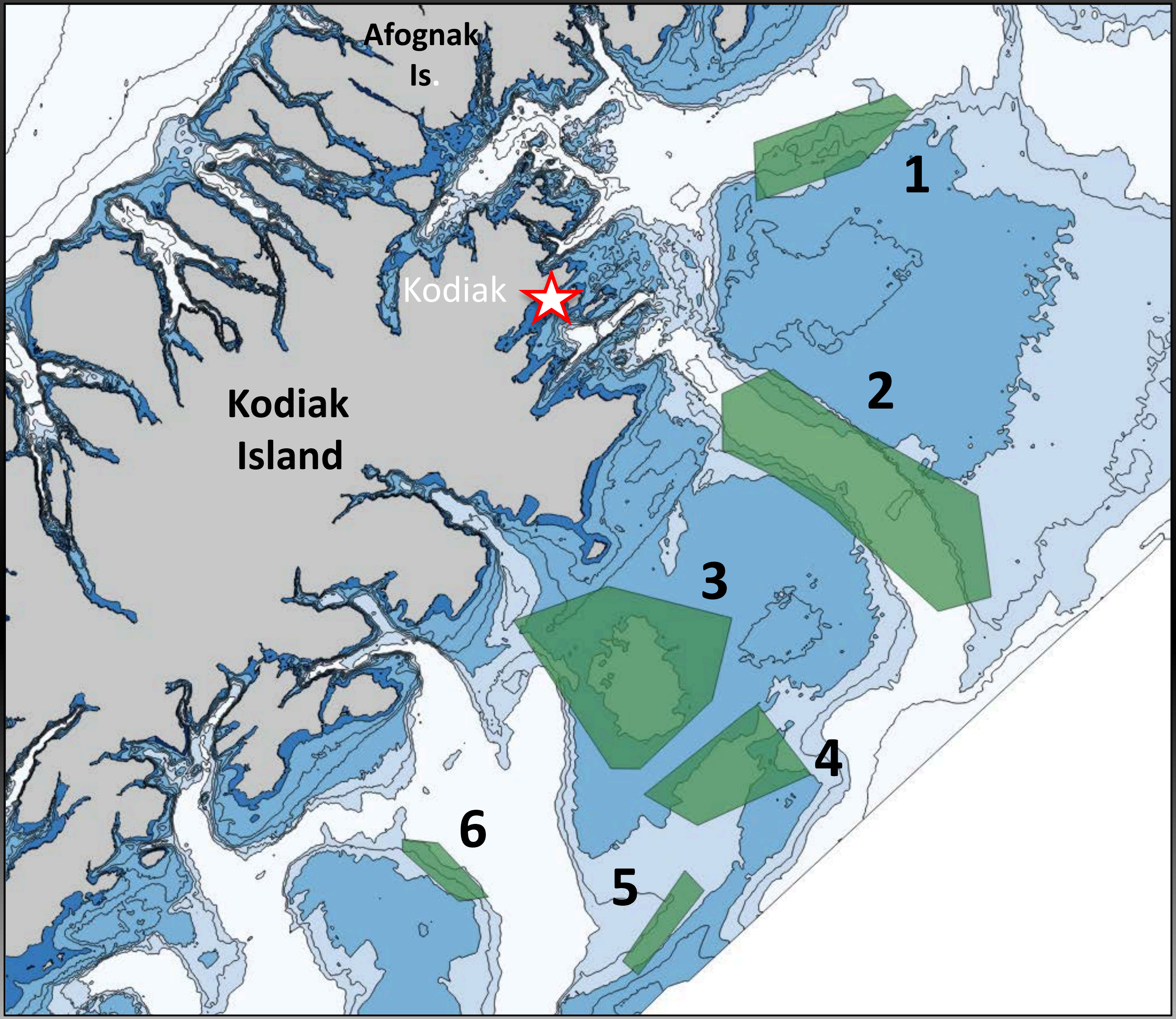
Pleuronectiformes (flatfishes)

Asteroidea (sea stars)

Bed-scale Differences
Example: Kodiak Northeast

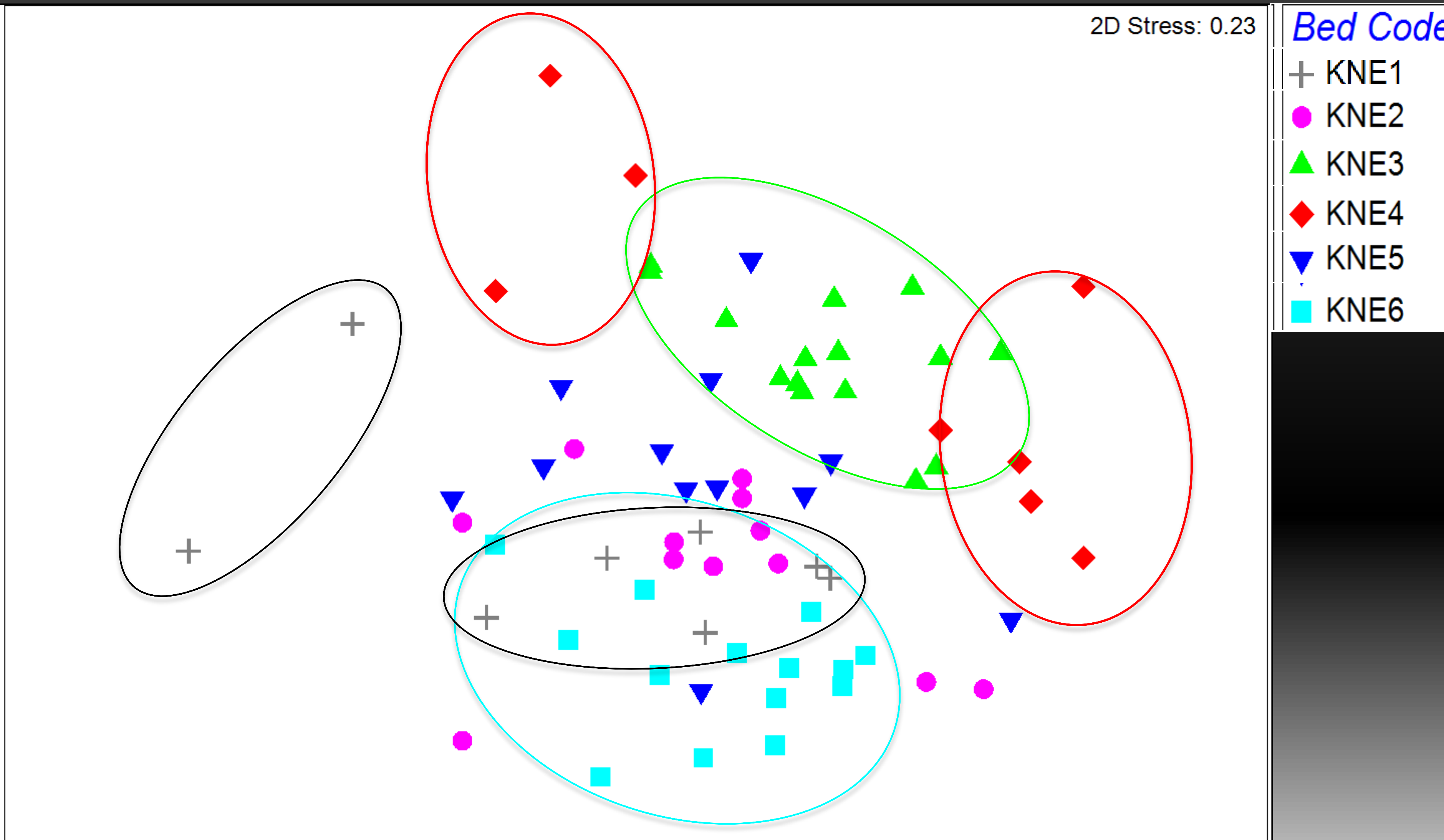


Bed-scale Differences
Example: Kodiak Northeast

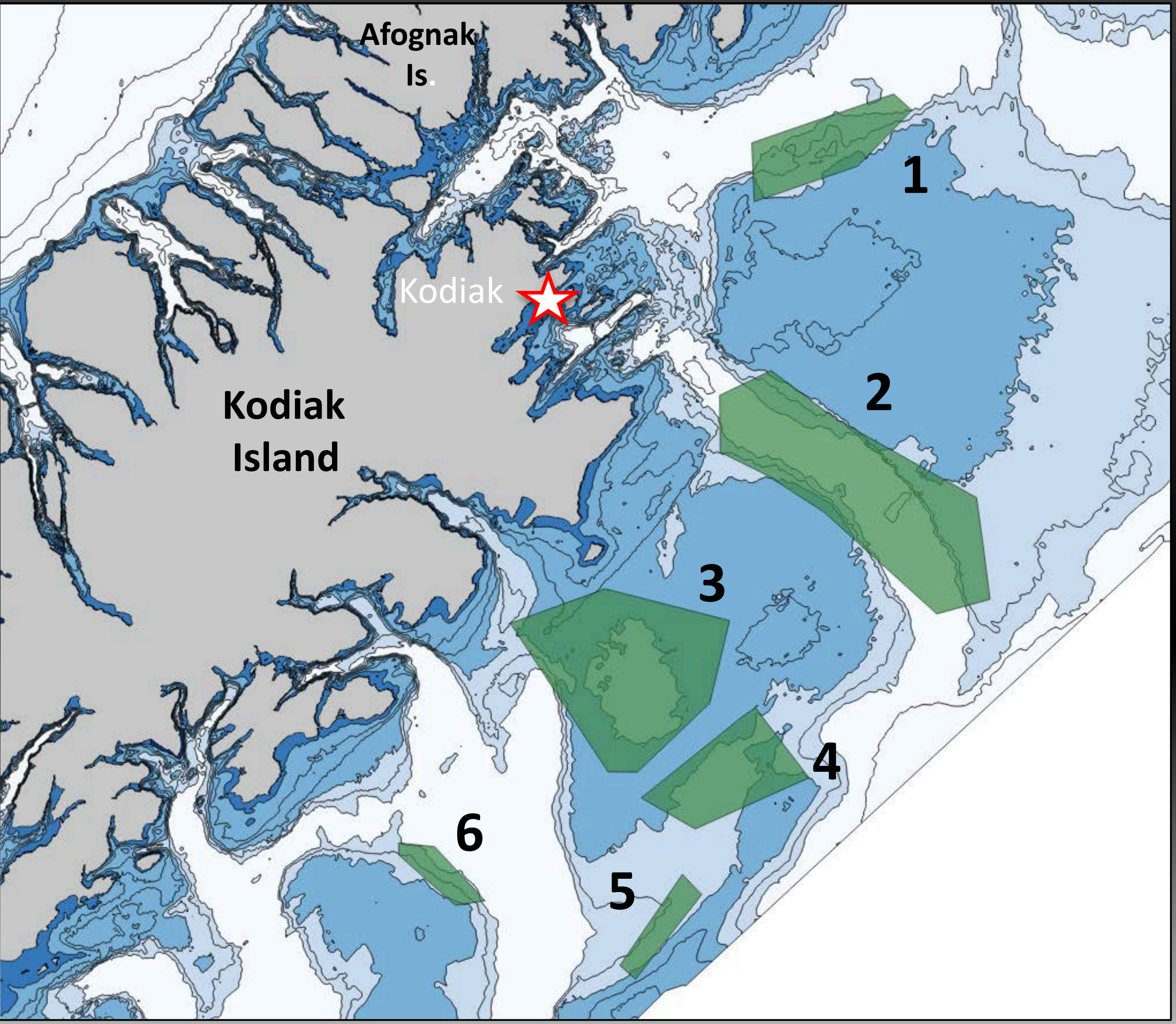


NMDS: Kodiak Northeast

(each point represents 1 yr)



Kodiak Northeast



ANOSIM:
(Clarke's R = 0.515,
P = 0.001)

Differences between all beds except Bed 1 & 2

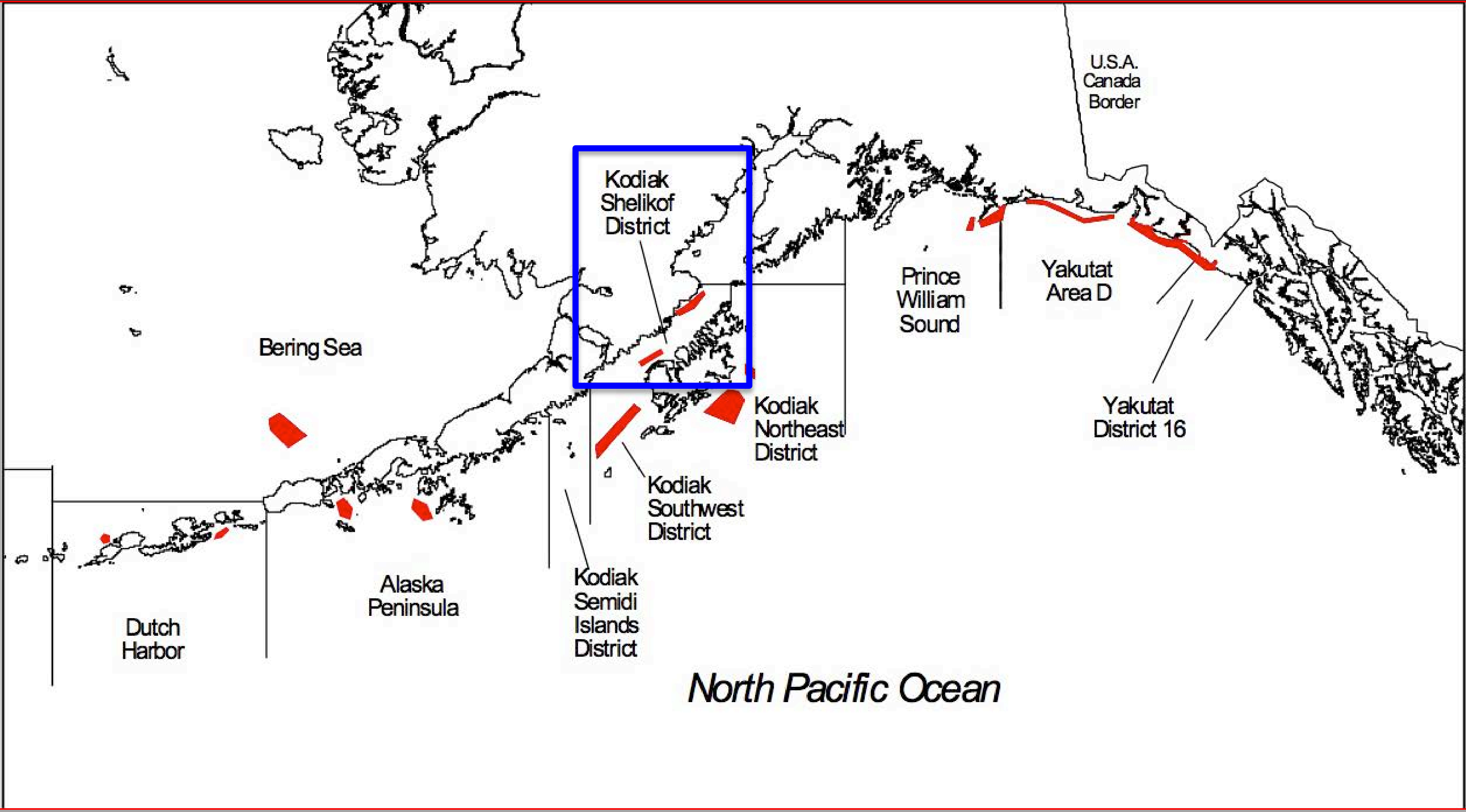
Strongest Difference: Bed 3 & Bed 6
Clarke's R= 0.872

Correlated with sediment & depth
(*P* = 0.001)

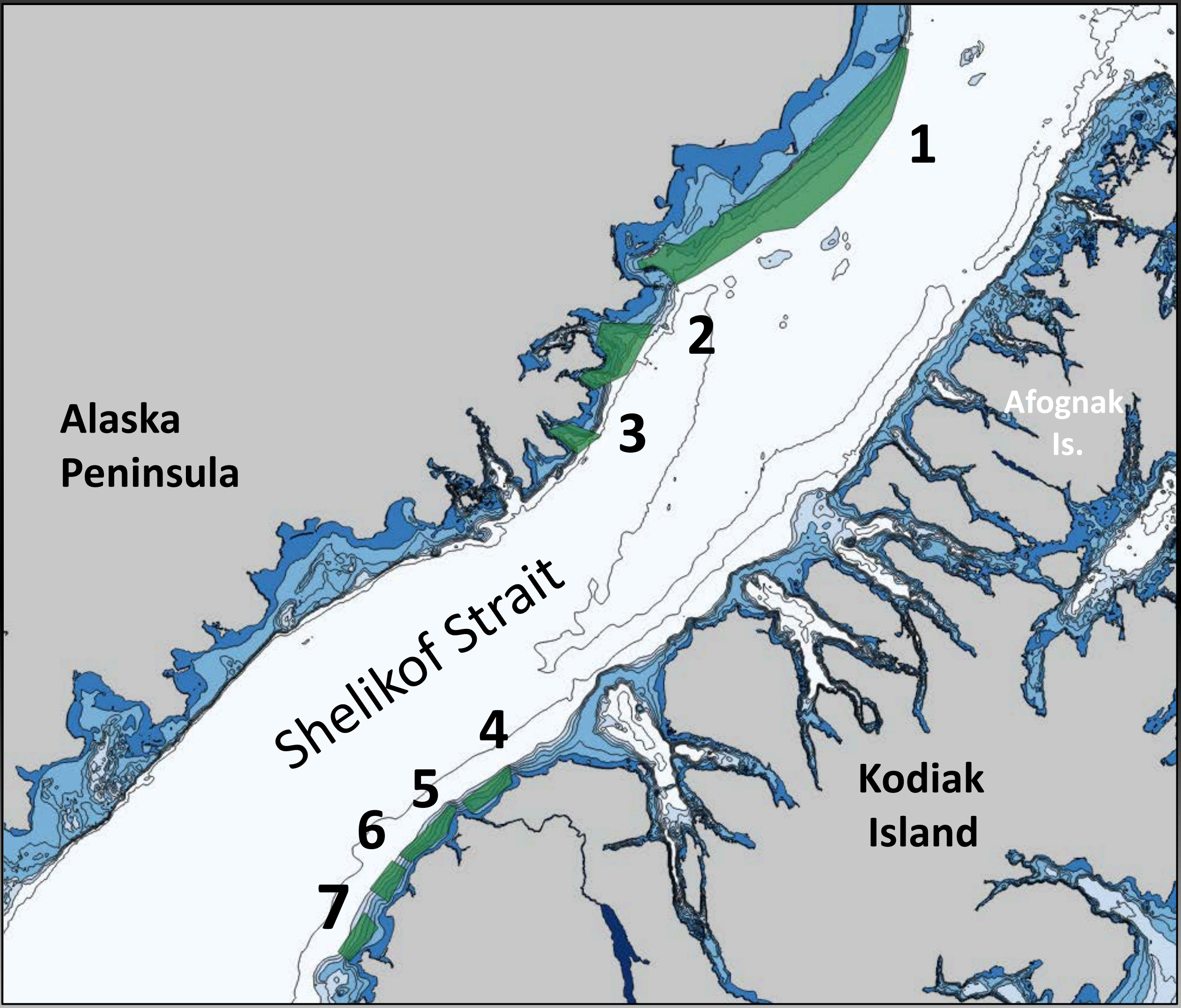
SIMPER: Kodiak Northeast

	Bed 3	**Bed 6**	
	68-88 m	80-117 m	
	Sand/gravel	Silty sand	
Taxa	**Avg. CPUE**	**Avg. CPUE**	**Contrib. %**
Actiniaria (Sea anemones)	**42.21**	**4.25**	6.97
Lithodidae (King crabs)	**2.58**	**36.55**	6.21
Rajidae (Skates)	**19.78**	**44.63**	4.67
Oregoniidae (Tanner crabs)	**22.21**	**42.33**	3.89
Asteroidea (Seas stars)	**57.58**	**37.78**	3.8
Ophiuridae (Brittle stars)	**15**	**0.14**	2.67
Luidiidae (Sea stars)	**14.26**	**0**	2.62
Paguridae (Hermit crabs)	**23.8**	**34.34**	2.35

Kodiak Shelikof District



Kodiak Shelikof District



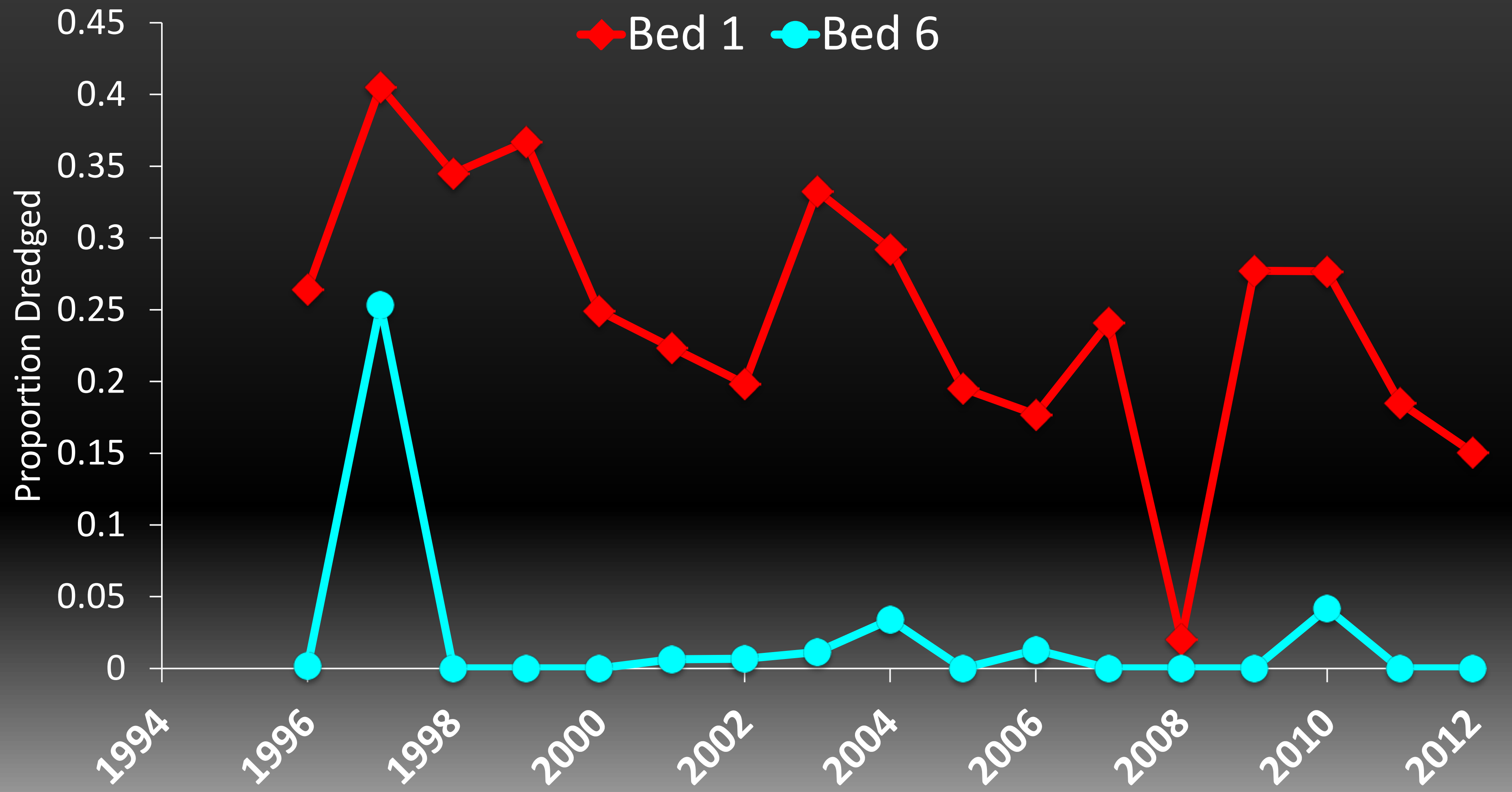
Greatest differences between beds 1 & 6

Correlated with dredging effort
1997: (P = 0.001)
2010: (P = 0.001)

Sediment data unavailable

Wide depth range

Kodiak Shelikof Dredging Effort 1996-2012



SIMPER: Kodiak Shelikof: Spatial Differences Due to Dredging?

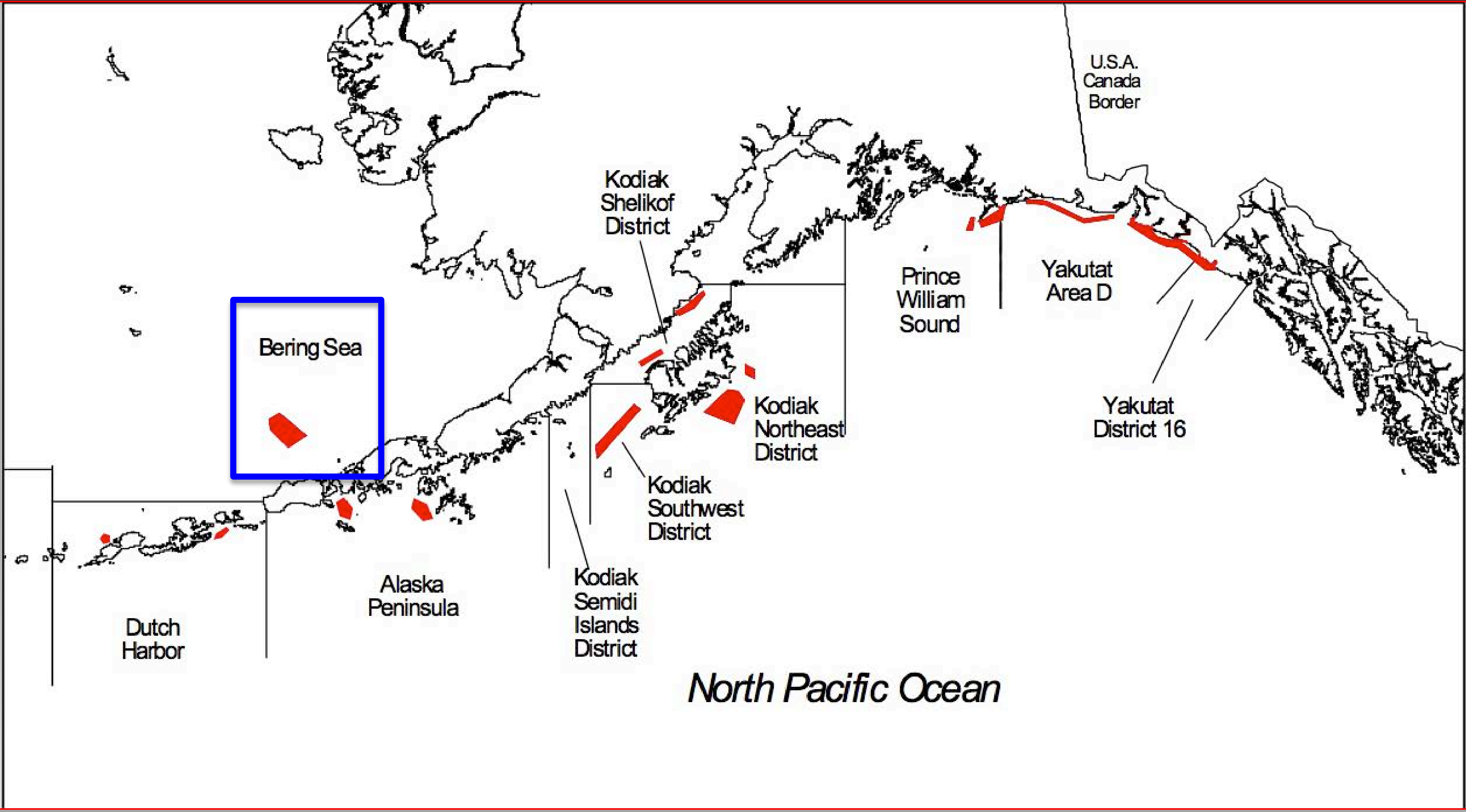
	Bed 1	Bed 6		
Taxa	**Avg. CPUE**	**Avg. CPUE**	**Contrib%**	**Cum.%**
Brachiopoda (Brachiopods)	3.22	49.19	7.18	7.18
Cancridae (Dungeness crabs)	4.72	45.02	5.97	13.15
Holothuroidea (Sea cucumbers)	3.02	33.67	4.29	17.44
Ascidiacea (Tunicates)	1.9	30.5	4.11	21.55
Polychaeta (Polychaete worms)	9.17	28.79	4.04	25.59
Rajidae (Skates)	49.69	51.63	3.55	29.14
Demospongiae (Sponges)	1.89	27.57	3.3	32.44
Gorgonocephalidae (Basket stars)	0.52	27.66	3.27	35.72

Temporal Analyses

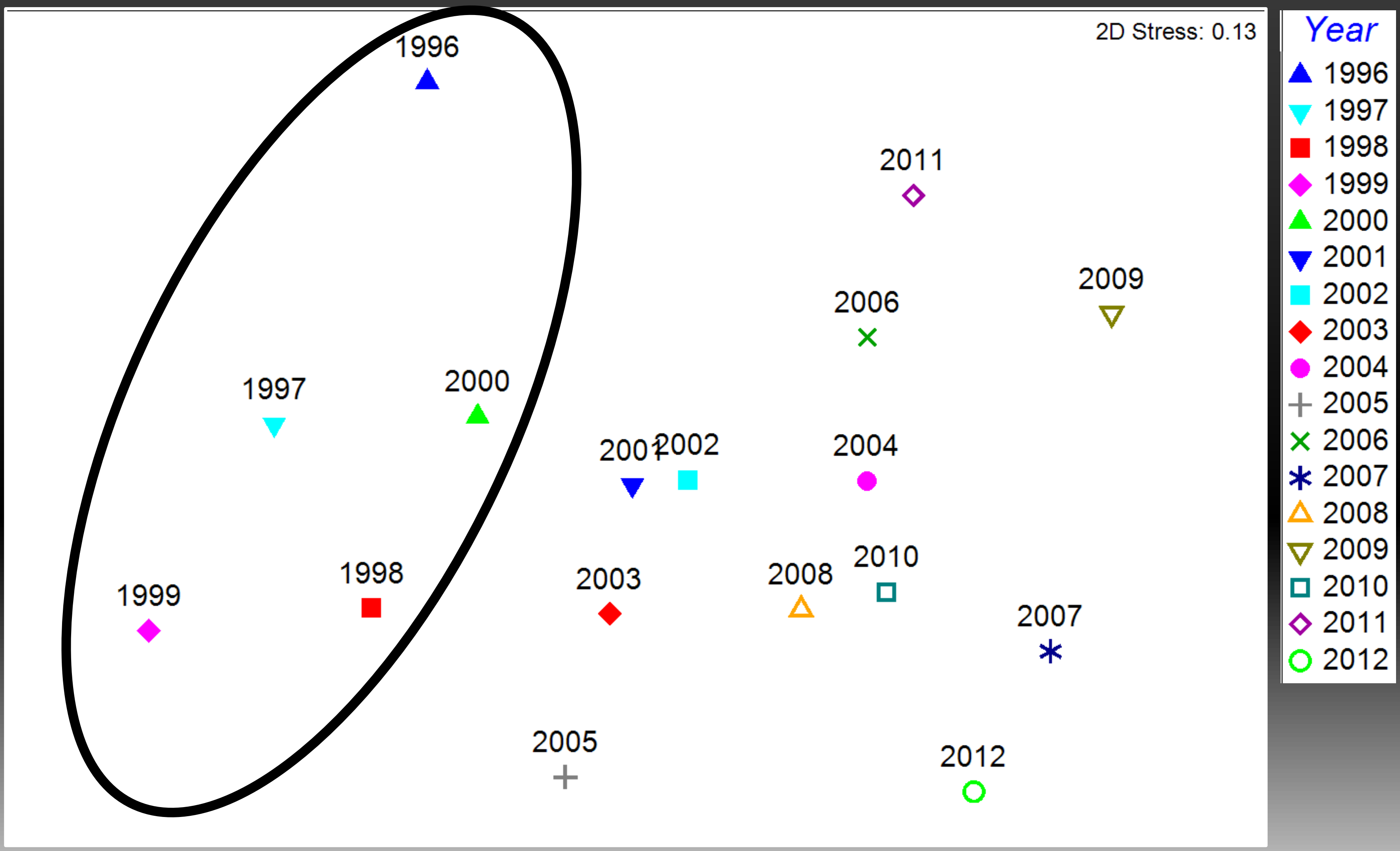
- Significant temporal differences for districts analyzed
- Changes in taxa were site-specific
- Split between 1996-1999 and 2000-2012
  - Changes over 2000-2012, as well, but less significant

District	ANOSIM (*P = 0.001*)	Spearman Rank (*P = 0.001*)
Kodiak Shelikof (Bed 1)	Clarke's R = 0.257	Dredging effort
Kodiak Northeast	Clarke's R = 0.220	Depth, dredging effort
Yakutat/D16/Prince William Sound	Clarke's R = 0.273	Freshwater discharge
Bering Sea	Clarke's R = 0.485	Dredging effort

Eastern Bering Sea



Temporal Analysis
Example: Eastern Bering Sea

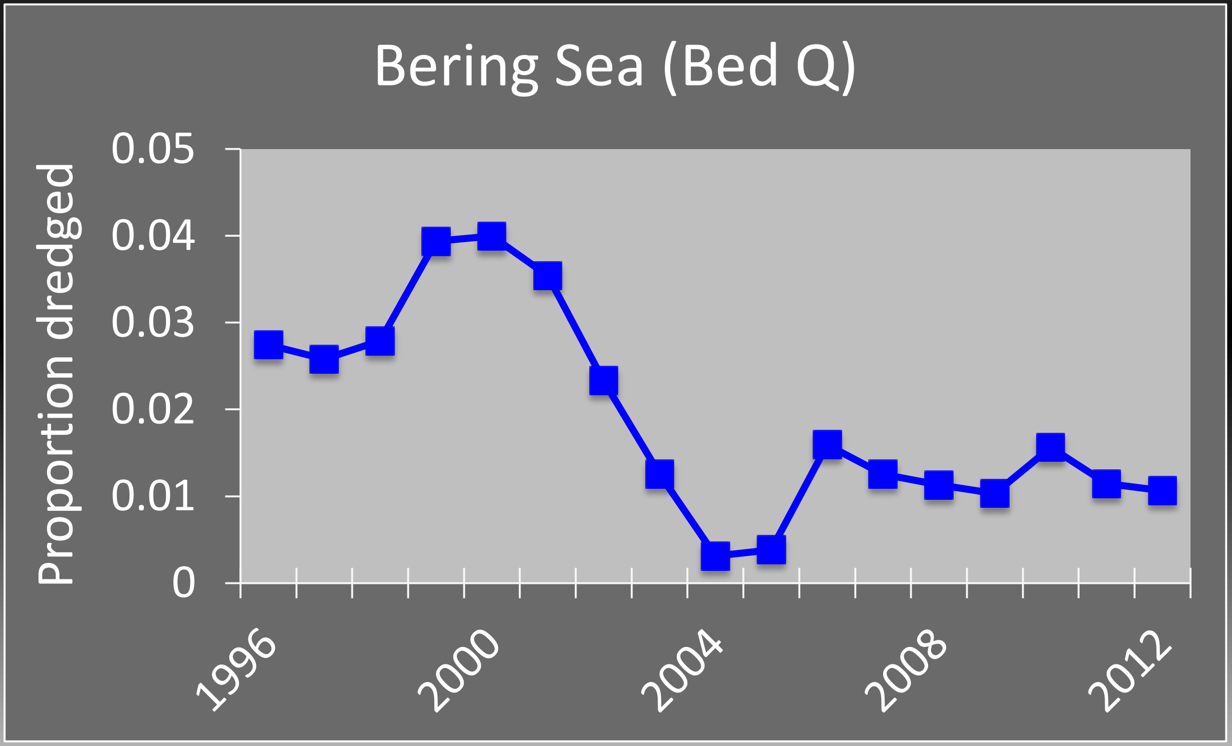


Changes in Bering Sea over 1996-2012

- Tanner crabs, scallops, flatfishes, skates
- Polychaeta, sponges, sea pens, whelks, barnacles
- Roundfish, jellyfish

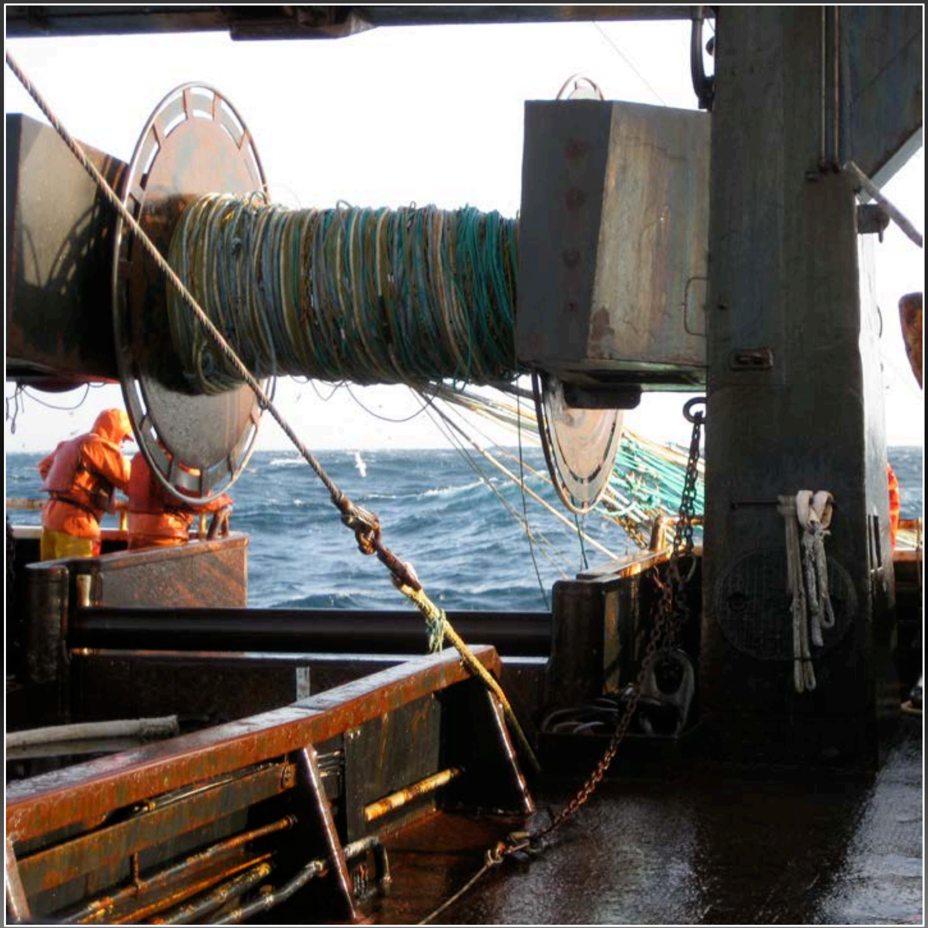
ANOSIM 1996-2012
(Clarke's R = 0.485, *P* = 0.001)

Dredging effort
(*P* = 0.001)



Trawling effort

- No significant correlation
  - Little overlap
- Proportion trawled: 0 – 0.224
  - Highest overlap in Bering Sea



Conclusions

- Spatial differences across all districts and between beds
  - Stronger patterns than temporal changes
  - Correlated with sediment, depth, and dredging effort (Kodiak Shelikof)
- Temporal changes over 1996 to 2012
  - Correlated with dredging effort and freshwater discharge
- Split between 1996-1999 and 2000-2012 may be due to:
  - Changes in observer sampling
  - Changes in fleet behavior with formation of cooperative
  - Other factors

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Questions?