The Effects of Dredging and Trawling on Weathervane Scallop Beds in Alaska, USA

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MESAS

Marine Ecosystem Sustainability in the Arctic and Subarctic

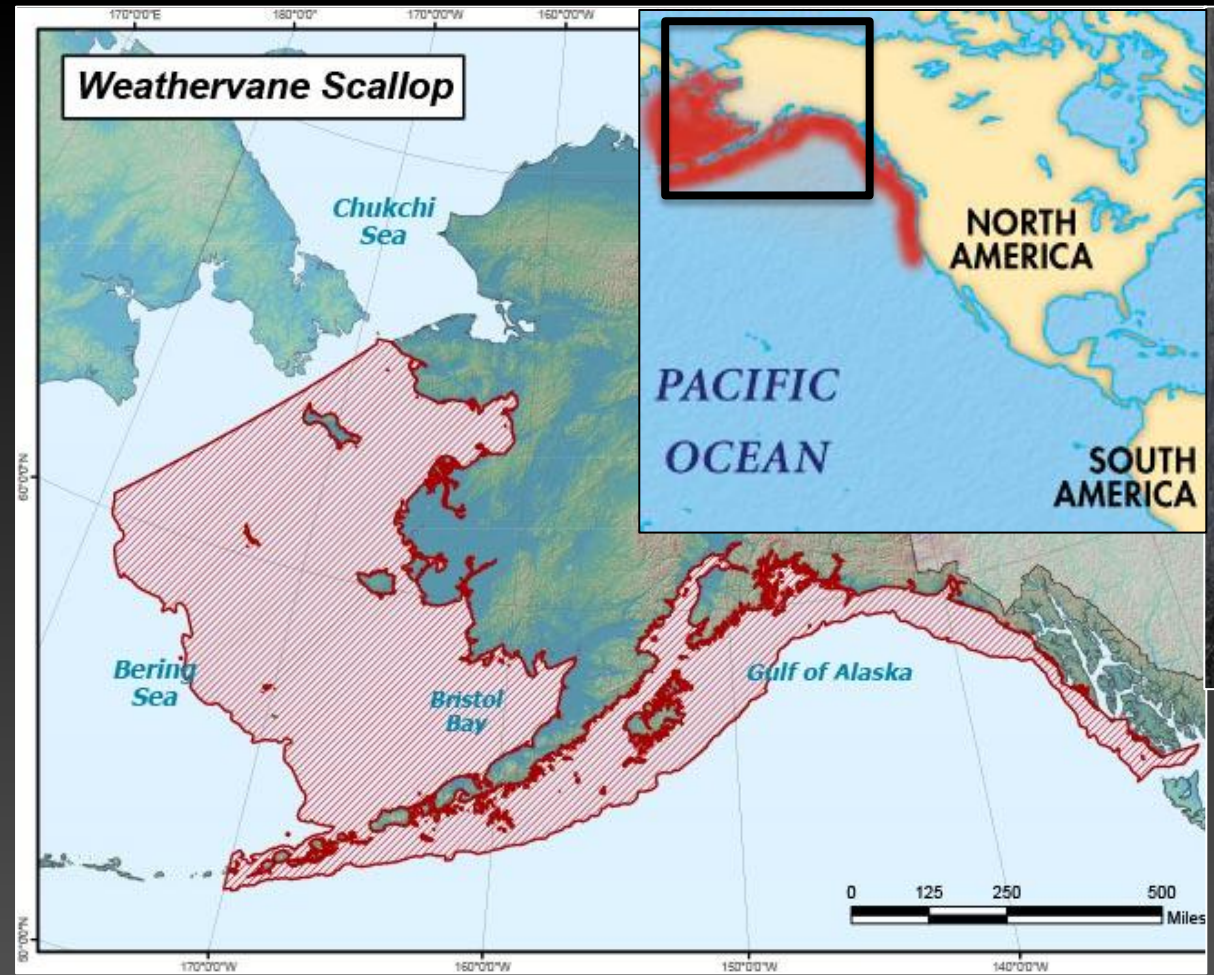
30 students

- Fisheries
- Marine Biology
- Indigenous Studies
- Anthropology

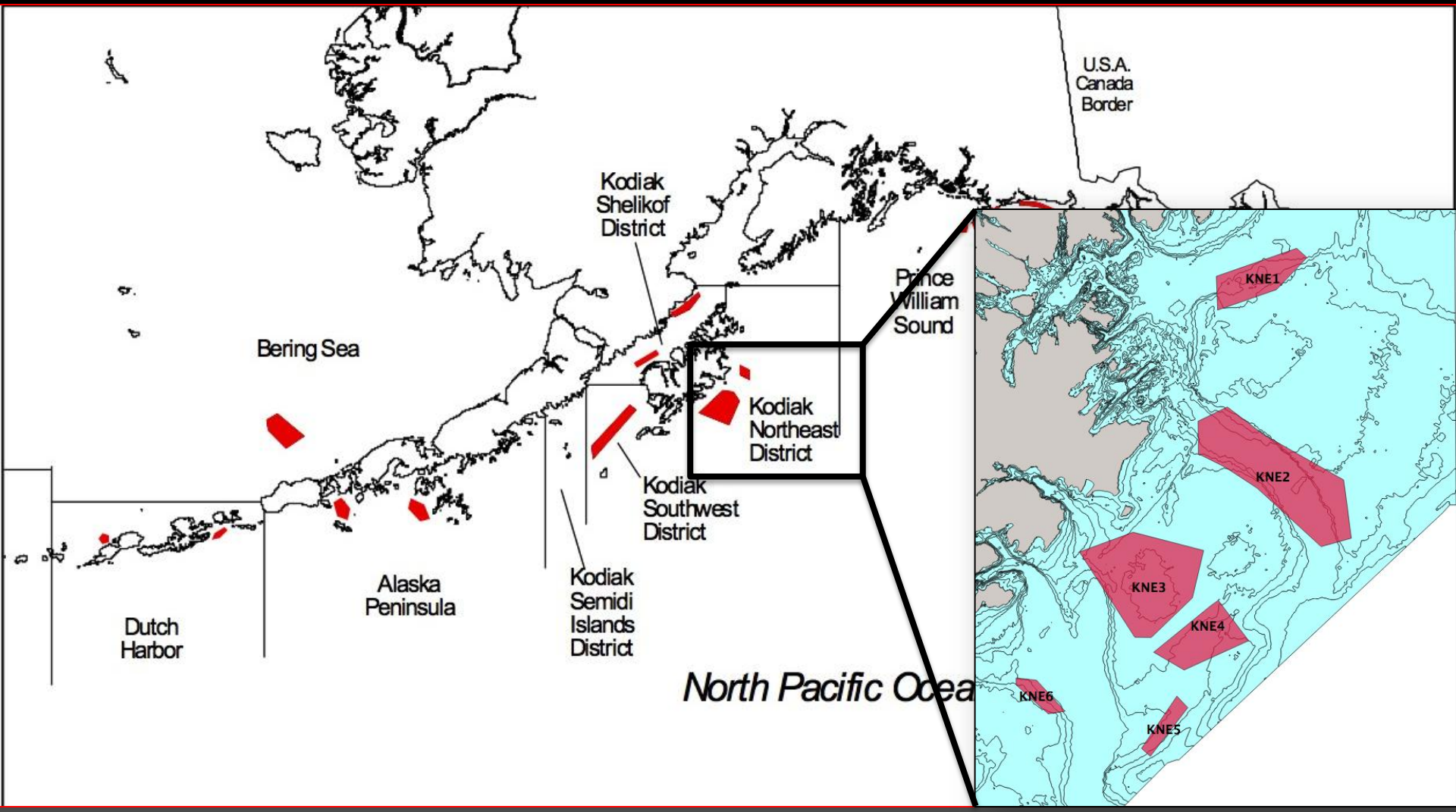
Weathervane Scallops

(*Patinopecten caurinus*)

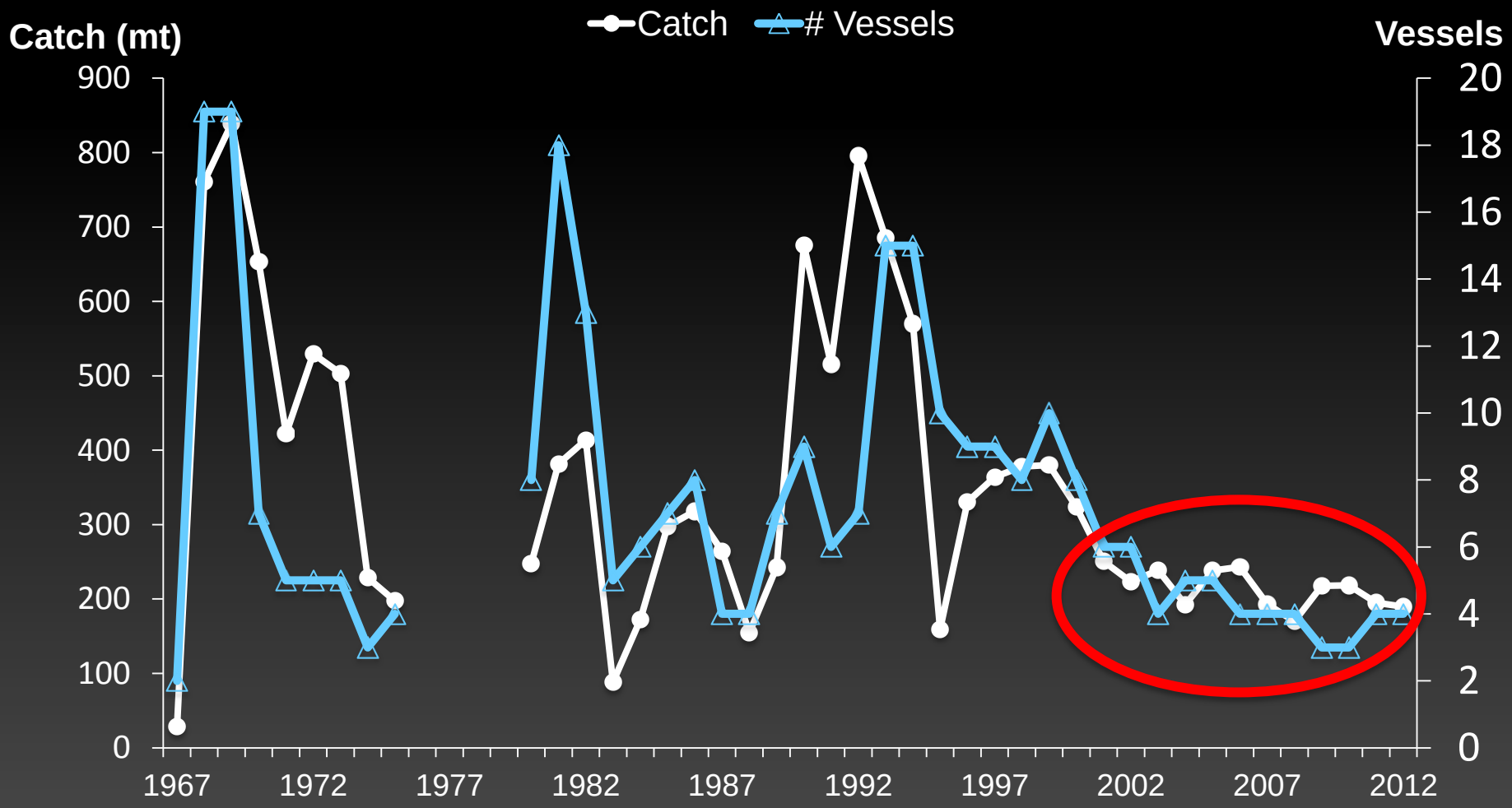
- Central California to eastern Bering Sea
- Beds: sand, gravelly sand, clayey silt (Turk 2001)



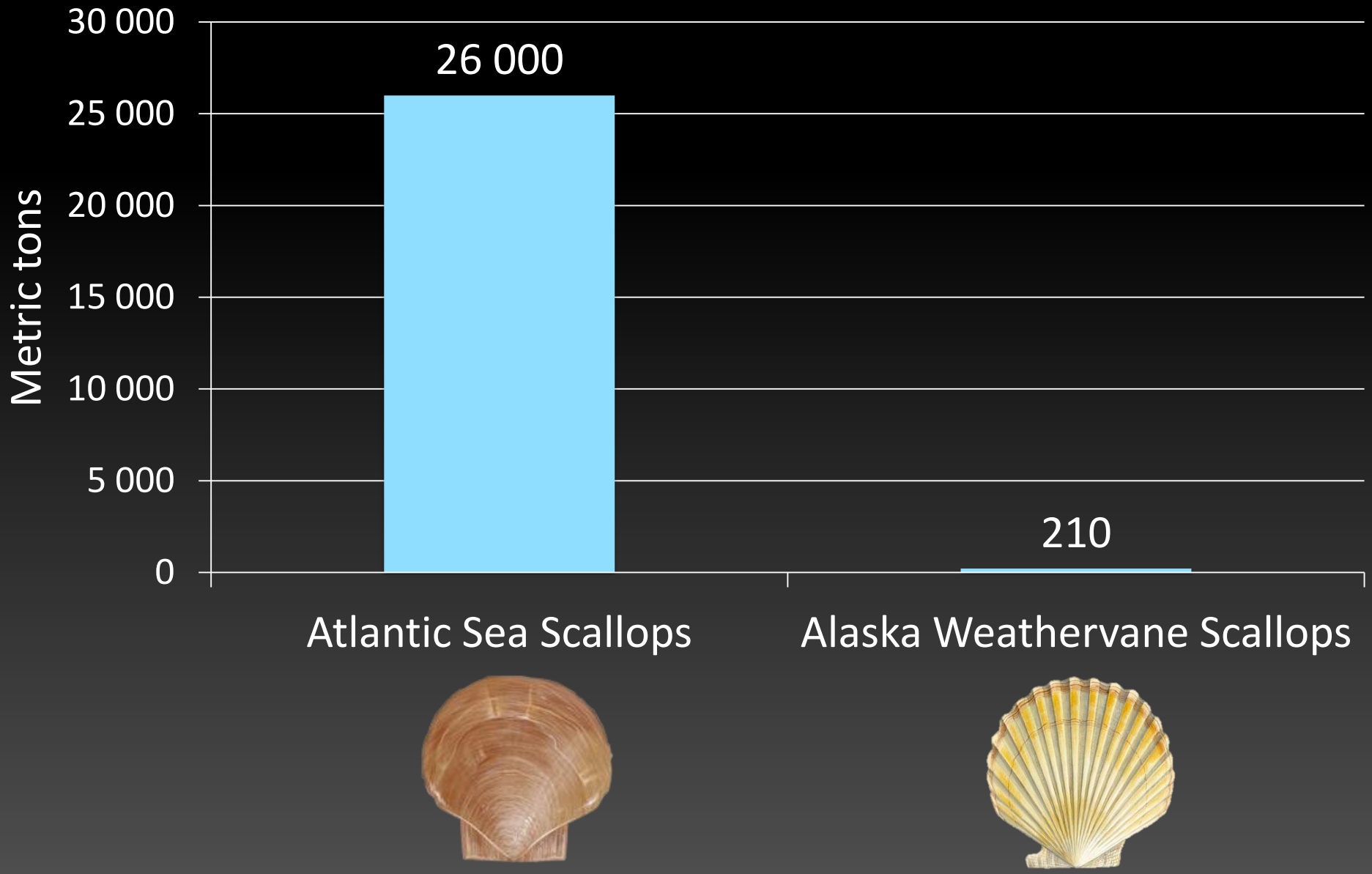
Weathervane Scallop Fishery



Weathervane Scallop Fishery

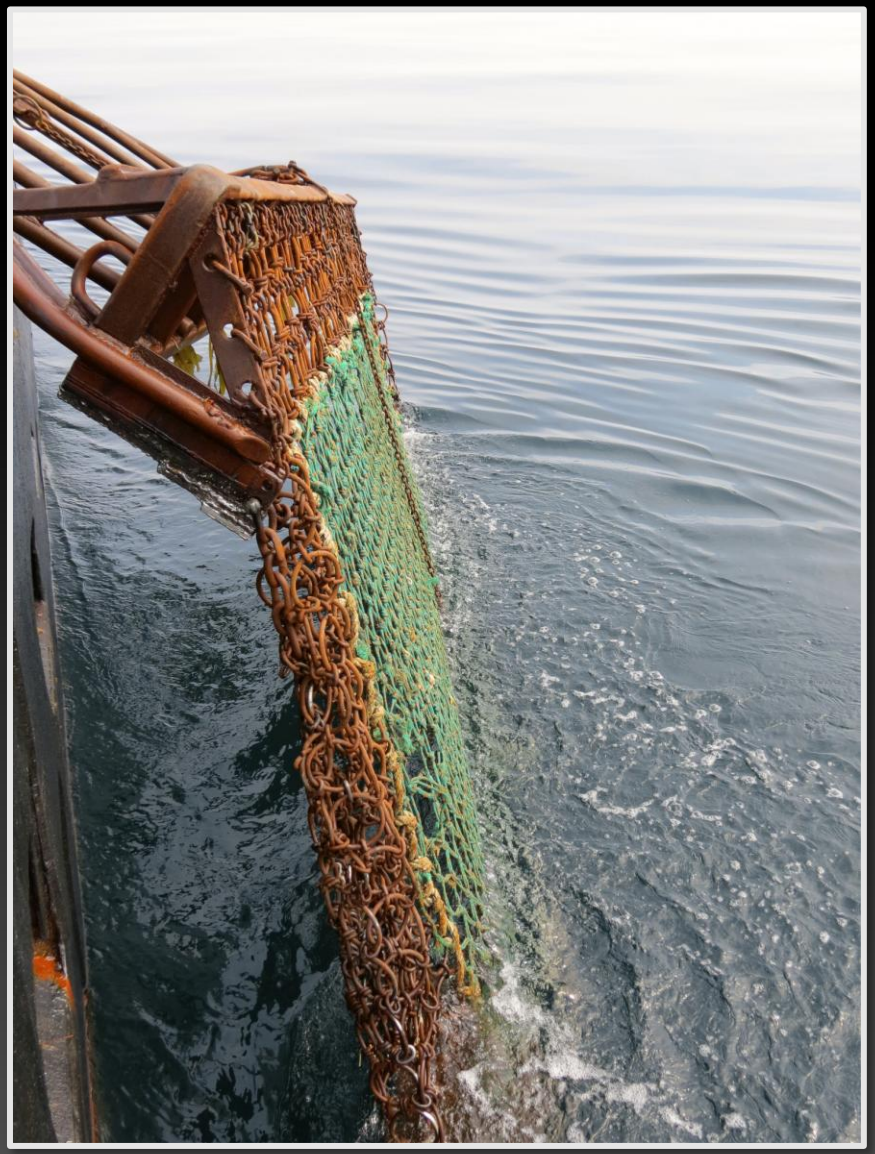


2010 Harvest of U.S. Scallops



Scallop Fishery Background

- 4 vessels
- 15 ft-wide dredges (4.6 m)
  - 4 inch rings
- 100% observer coverage
  - 1 haul/day



Fishery Bycatch

Fishery Concerns

- Unknown effects of dredging
  - Overlap with other commercial fisheries
  - Tanner crab: lack of recovery
- ↓ Catch per unit effort

Research Objectives

1) Quantify spatial and temporal patterns in benthic community composition

1) Relate patterns to environmental and anthropogenic variables

Methods

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

Methods

- Spatial
  - 1997, 2000, 2010
  - District-scale
  - Bed-scale
- Temporal (1996-2012)
- **Environmental variables**
  - Depth
  - Surface sediments
  - Near-bottom temperature
  - Freshwater input
    - Proxy for surface currents

Anthropogenic Variables

- Trawling effort

  National Marine Fisheries Service

  "Catch in Areas Database"

  - Bottom and pelagic trawls
  - Proportion of bed trawled

- Dredging effort
  - Proportion of bed dredged

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

Results

- 4 key players: Scallops, Skates, Flatfishes, Asteroidea sea stars

- Significant spatial and temporal differences in all districts analyzed
  - Small (< 50 km) and large (> 1000 km) scales
- Spatial:

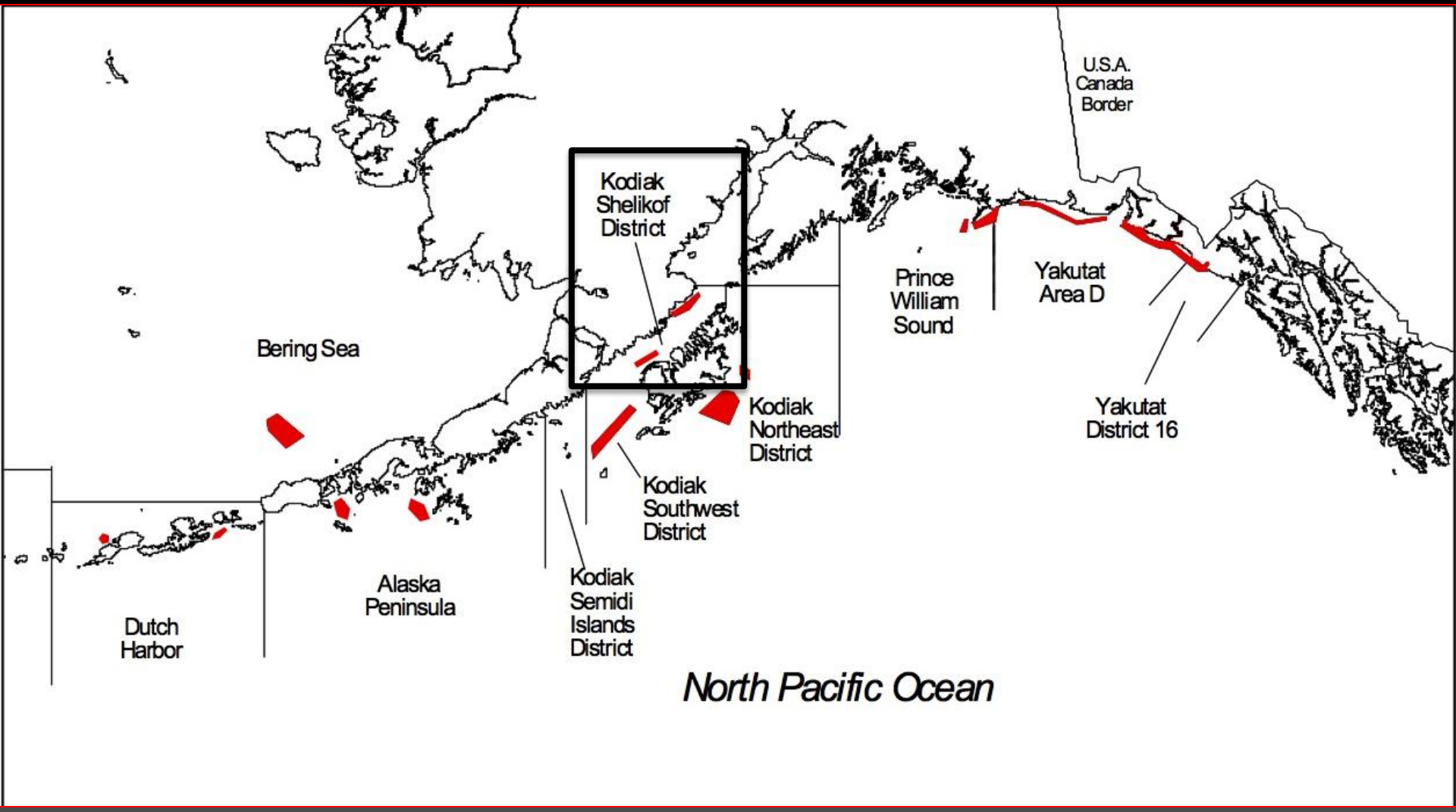
  Correlated with sediment, depth, dredging effort
- Temporal:

  Correlated with dredging effort, freshwater discharge

Trawling effort

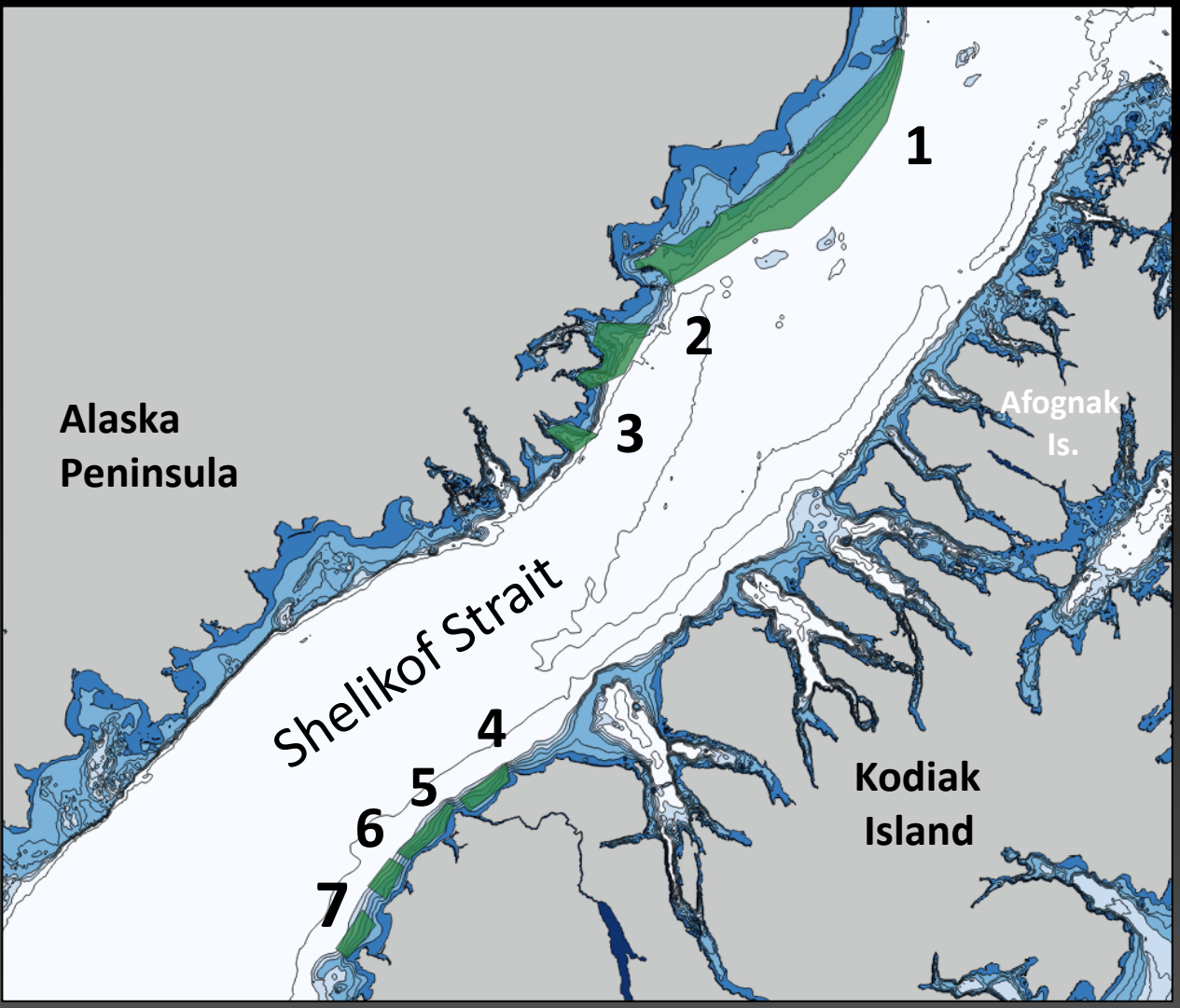
- No significant correlation
  - Little overlap
- Proportion trawled: 0 – 0.224
  - Highest overlap in Bering Sea

Weathervane Scallop Fishery



Spatial Example

Kodiak Shelikof District



Correlated with dredging effort

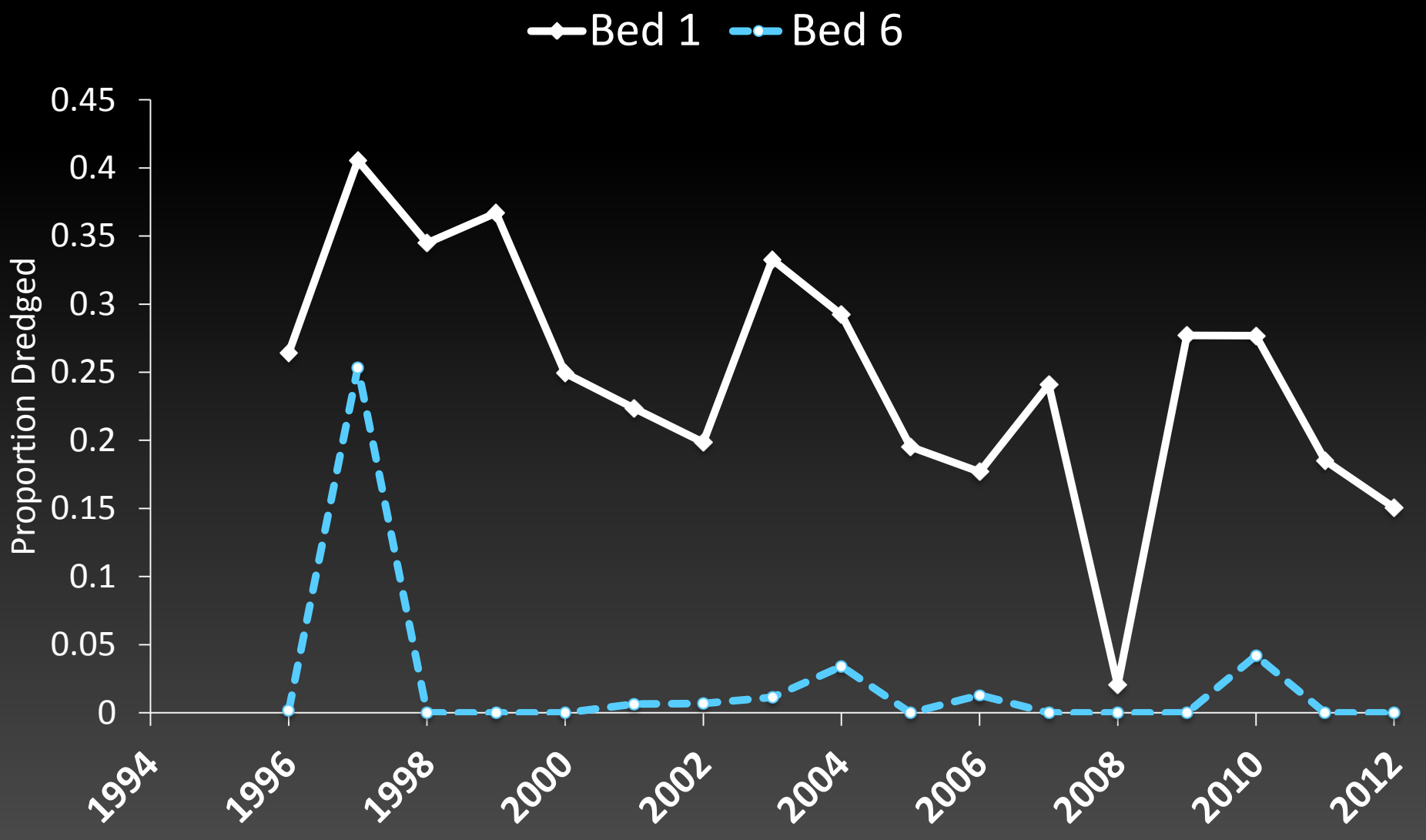
1997: (ρ = 0.247, P = 0.001)

2010: (ρ = 0.289, P = 0.001)

Sediment data unavailable

Wide depth range

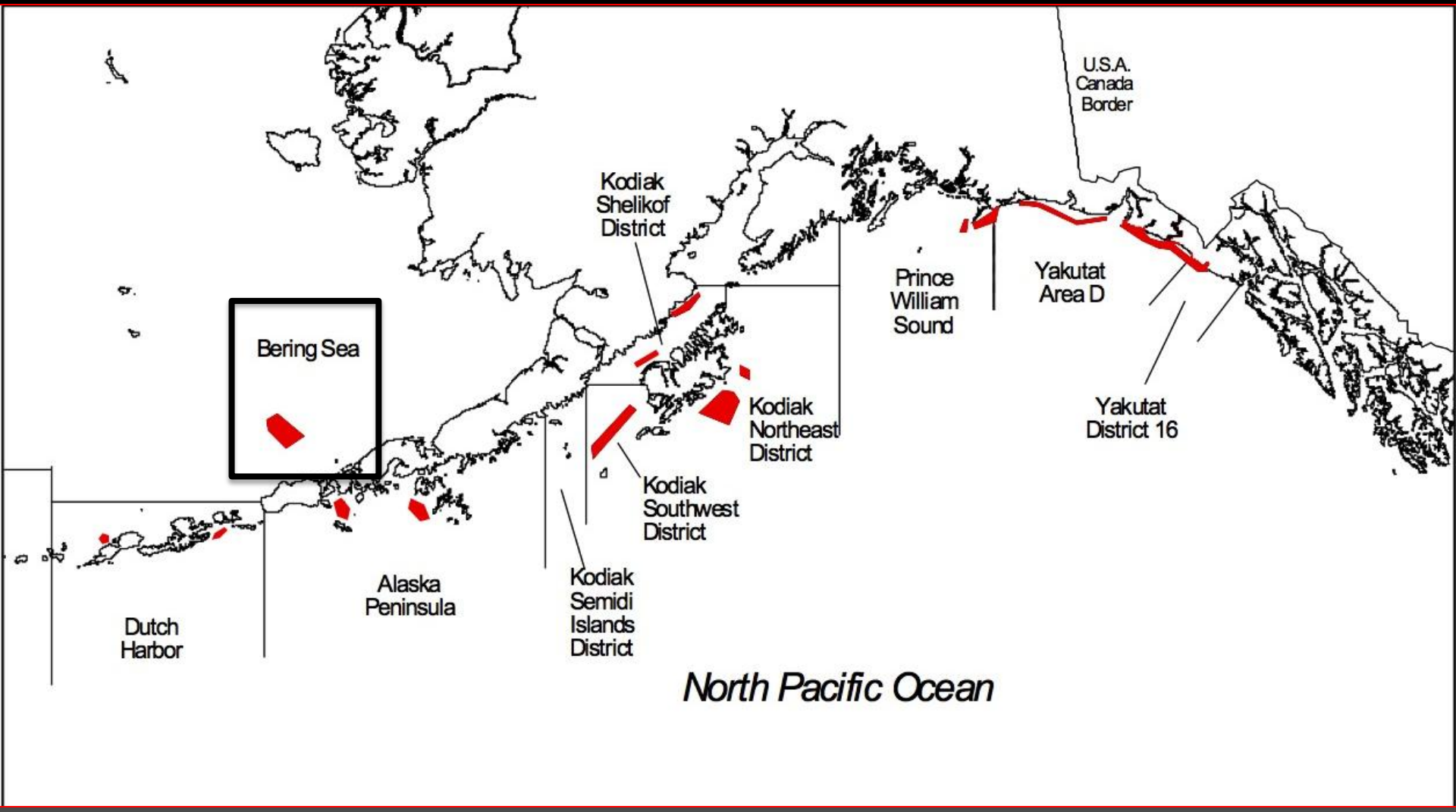
Kodiak Shelikof Dredging Effort 1996-2012



Kodiak Shelikof: Spatial Differences

Taxa	Bed 1 Avg. CPUE	Bed 6 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

Weathervane Scallop Fishery



Bering Sea: 1996-2012

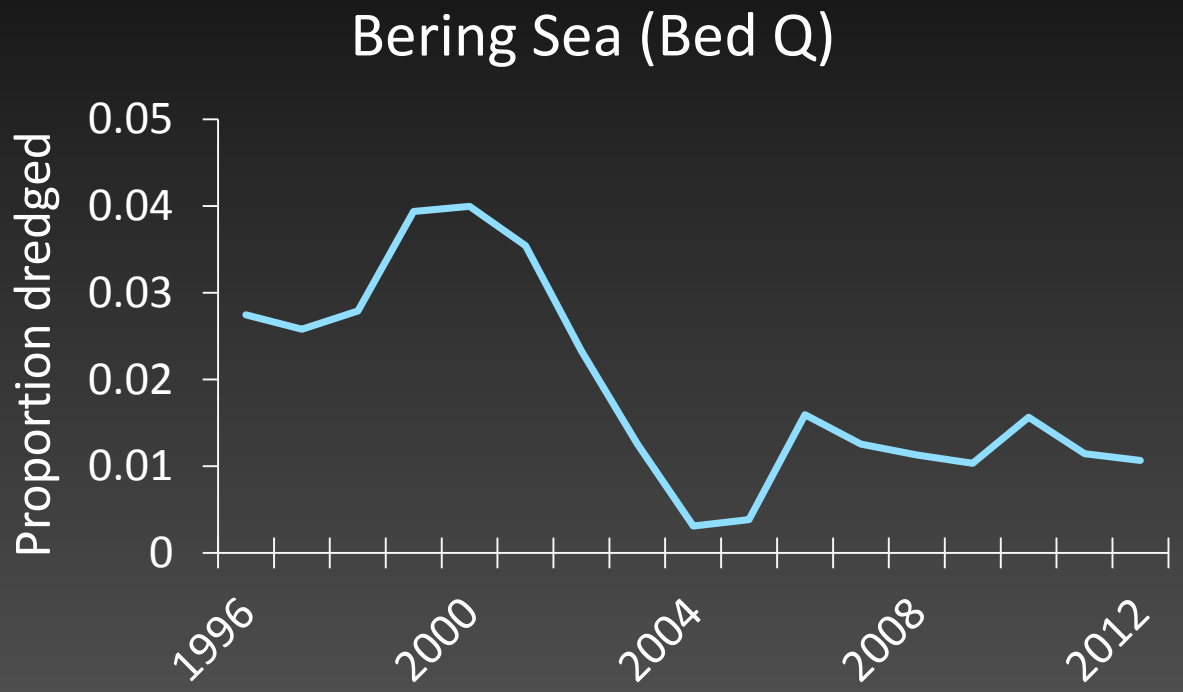
Tanner crabs, scallops, flatfishes, skates

Polychaeta, sponges, sea pens, whelks, barnacles

Roundfish, jellyfish

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

Dredging effort
(ρ = 0.172, *P* = 0.001)



Conclusions

- Weak, significant correlation between dredging and benthic composition
  - Spatially-dependent
    - No uniform changes in taxa across districts

Conclusions

- Temporal changes hard to distinguish
  - Interannual variability
  - Long life spans
  - Dynamic habitat

Implications

- Baseline data
- Mitigation:
  - Closed areas
  - Conservative harvest limits
  - Low effort
- Future research:
  - Controlled studies (BACI)
  - Interspecies interactions
    - (Masuda and Stone 2003)
  - Discard mortality studies

Alaska CamSled

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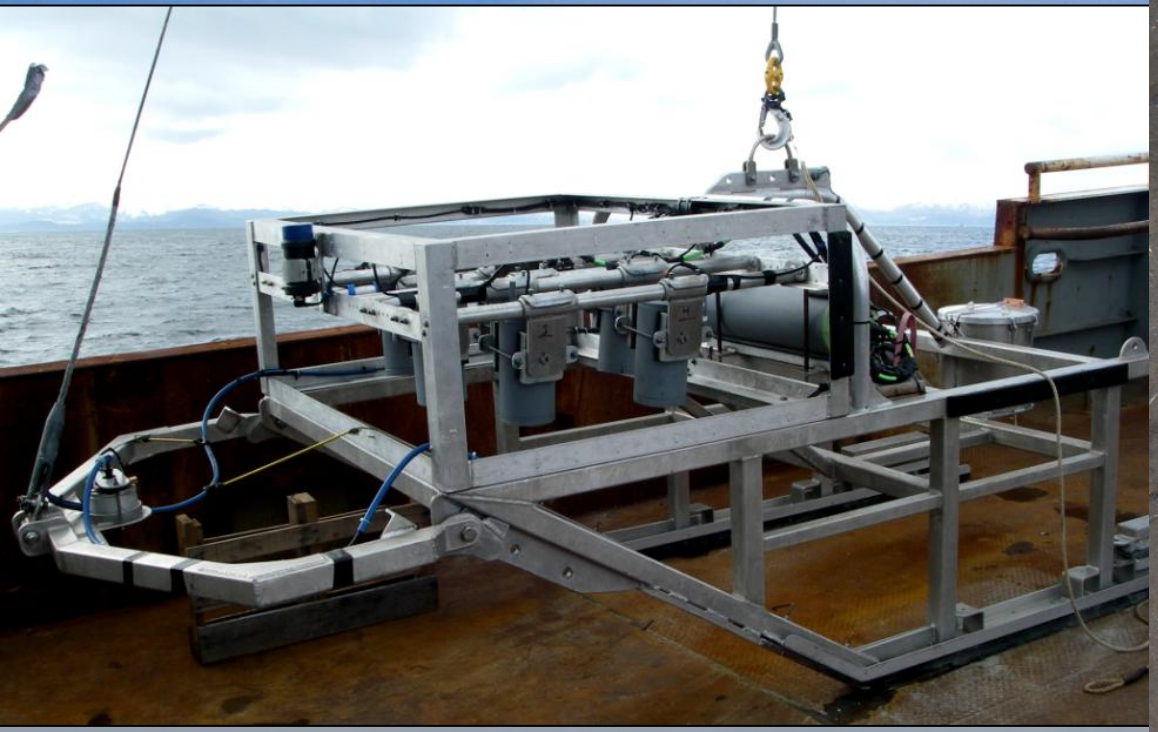
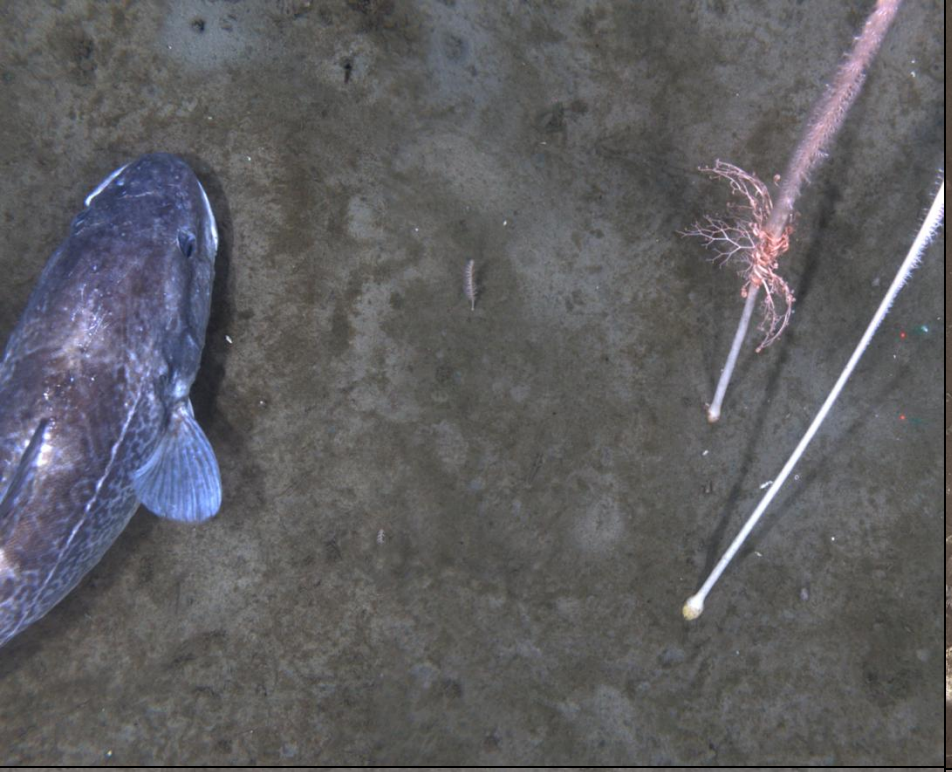
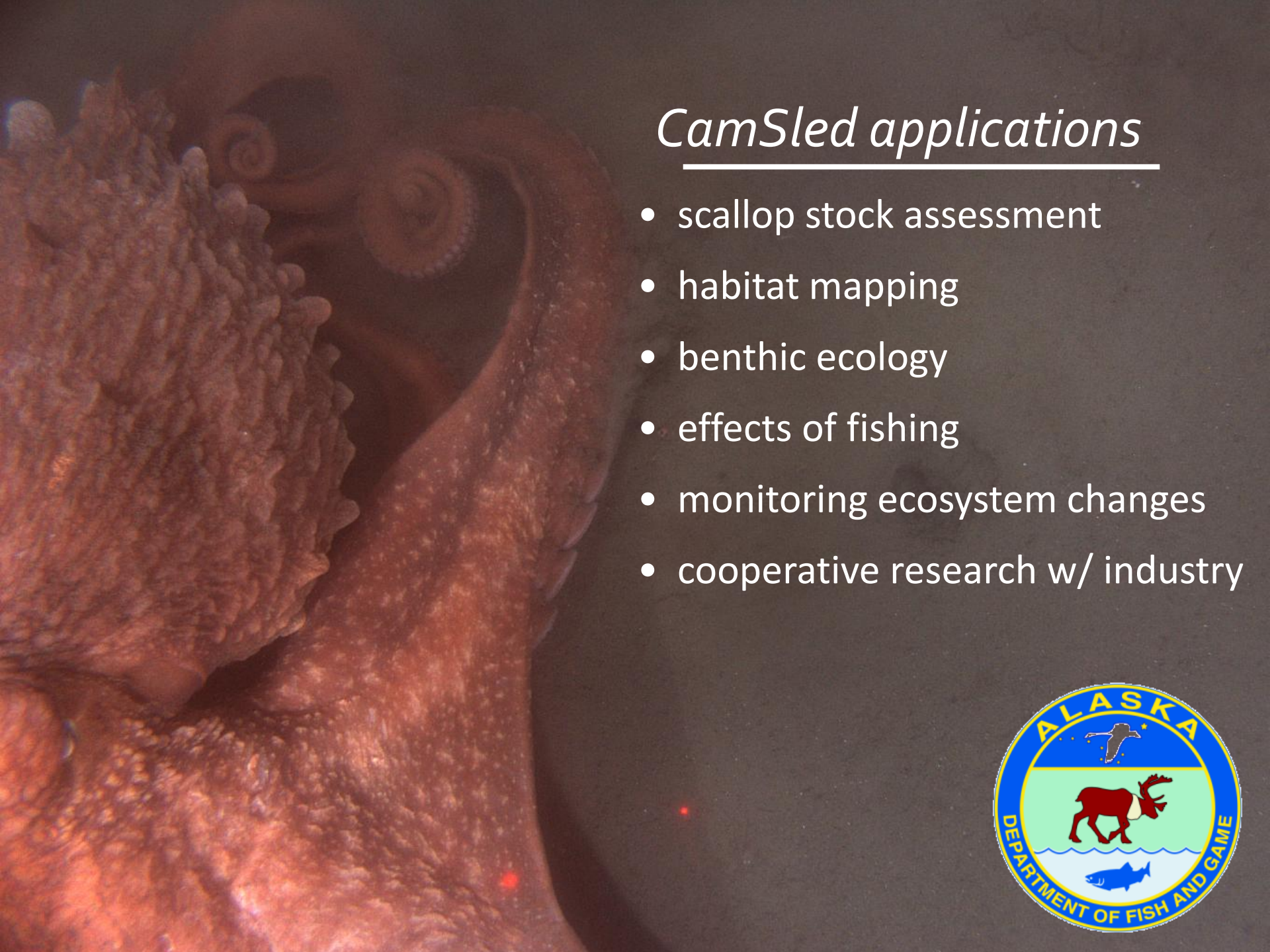


Over 2,800 km towed and 7 million images collected in the Gulf of Alaska and Bering Sea

System description

- megapixel GigE Vision™ camera
- 6 xenon flashlamp strobes
- Gigabit Ethernet telemetry
- armored fiber optic tow cable
- real-time monitoring/camera control
- 1 m-wide seafloor FOV
- 5 frames/sec, 40+ gigabytes/hour image data to disk
- tow speed 8 km/hour
- deployed from commercial fishing vessels >20 m LOA

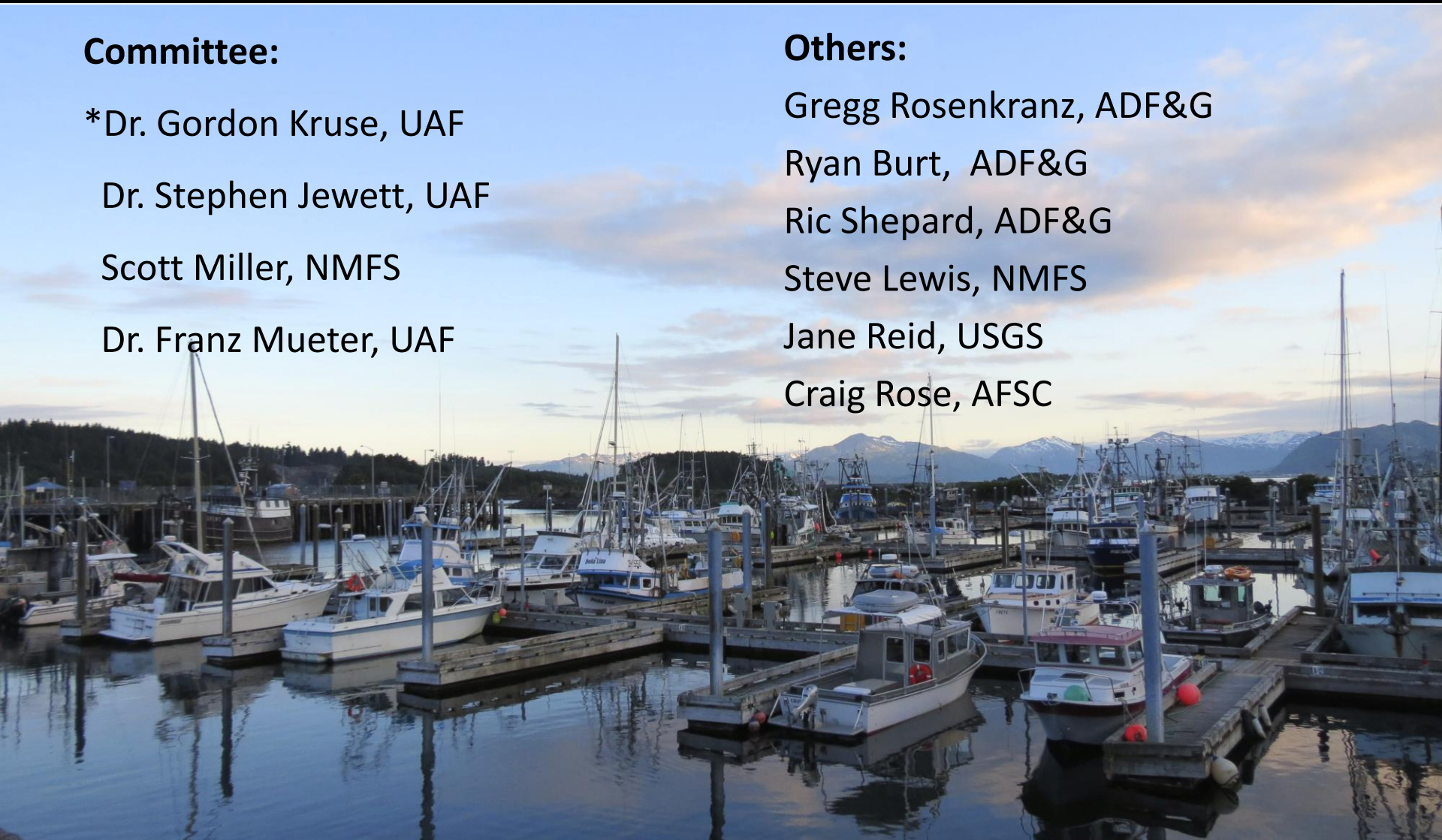


CamSled applications

- scallop stock assessment
- habitat mapping
- benthic ecology
- effects of fishing
- monitoring ecosystem changes
- cooperative research w/ industry

Thank you!



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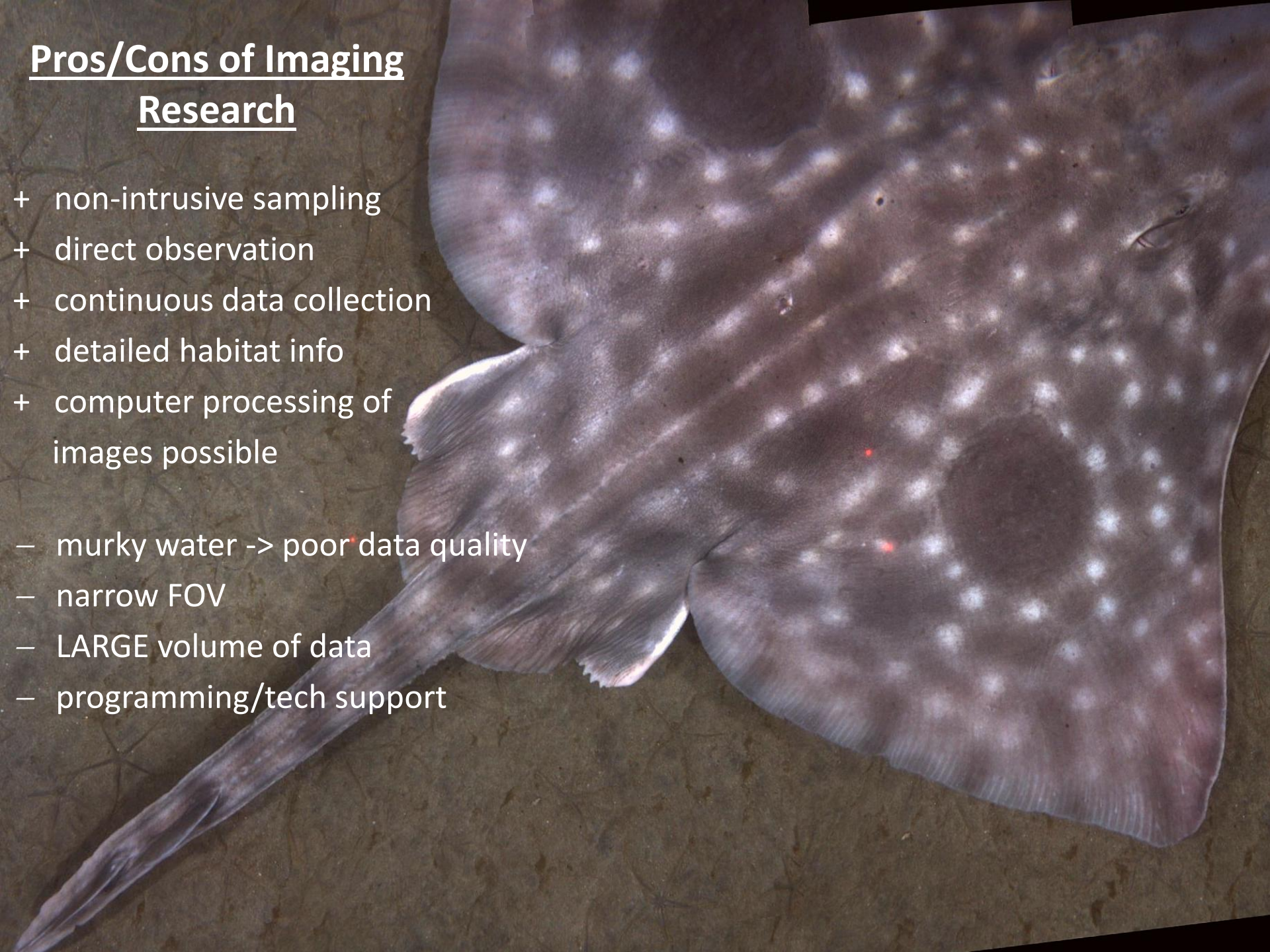
- NSF Graduate Research Fellowship Program
- Northern Gulf of Alaska Applied Research Award
- H. Richard Carlson Fellowship

Questions?

Pros/Cons of Imaging Research

+ non-intrusive sampling
+ direct observation
+ continuous data collection
+ detailed habitat info
+ computer processing of images possible

– murky water -> poor data quality
– narrow FOV
– LARGE volume of data
– programming/tech support

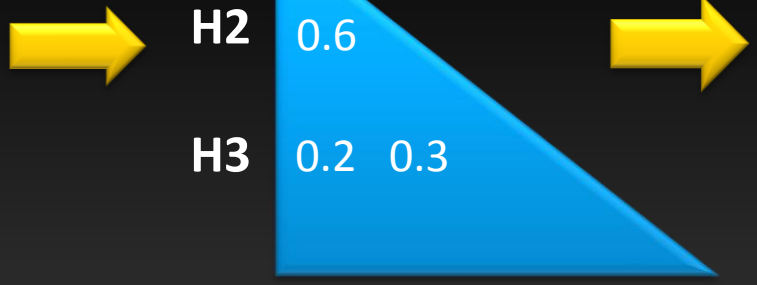


Distance-based measures

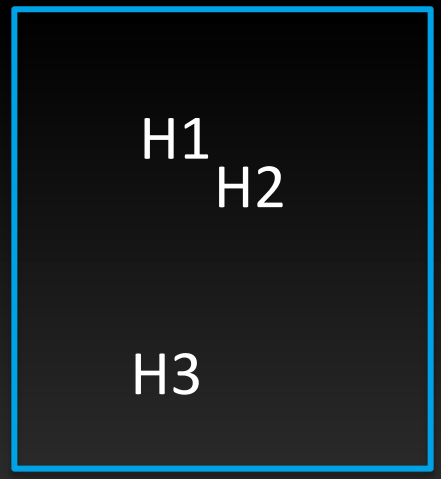
Sampled Hauls

	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



Similarity matrix



Ordination (NMDS)