Development of an integrated benthic survey

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Outline

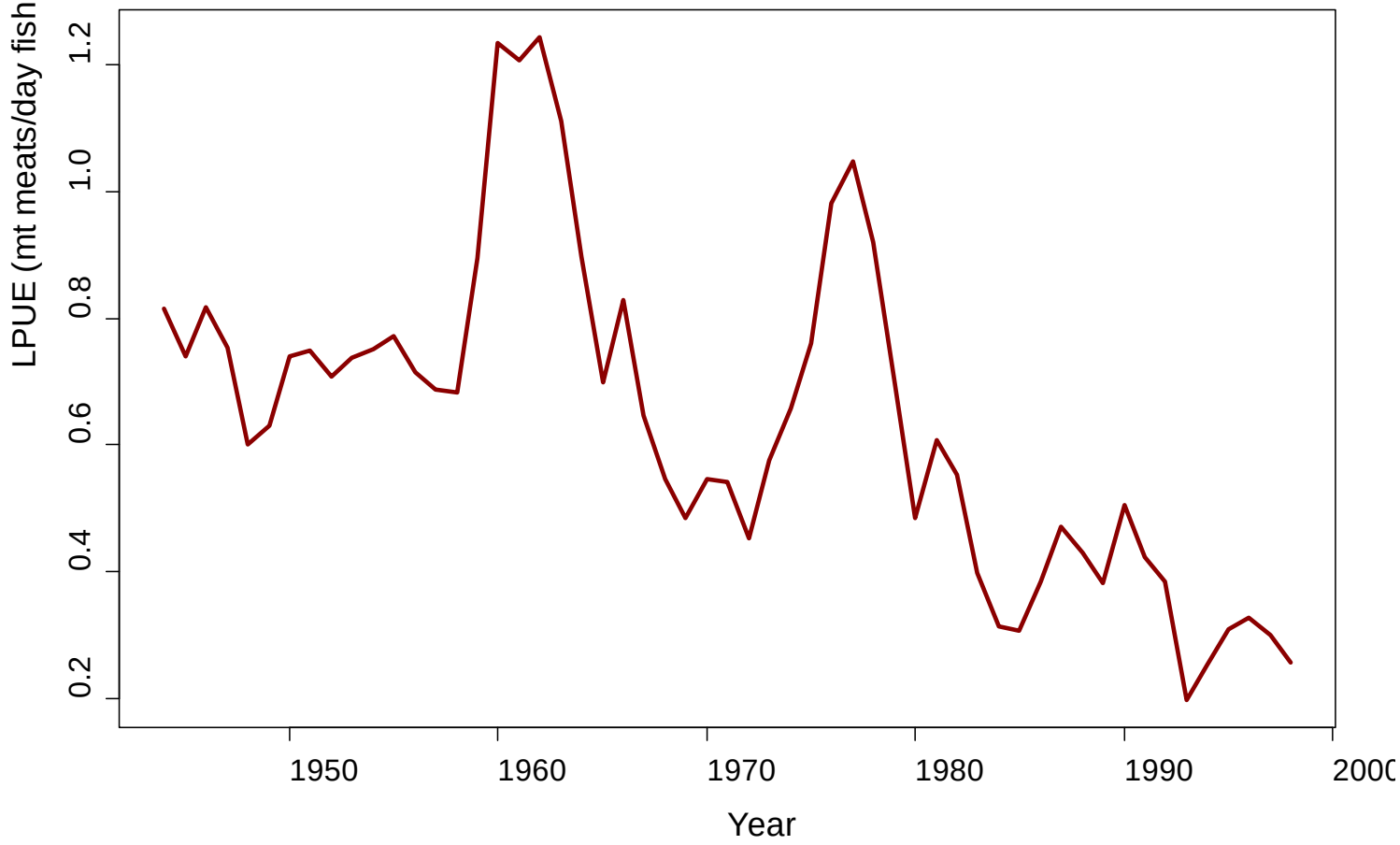
US sea scallop fishery and management

Traditional sea scallop dredge survey

HabCam system

Integrated benthic survey with HabCam and dredge sampling

Catch per day fished (approximately proportion to exploitable biomass) Georges Bank, 1944-1998



Long-term decline in catch rates due to "ratcheting-up" of fishing effort

Changes to management starting in 1994

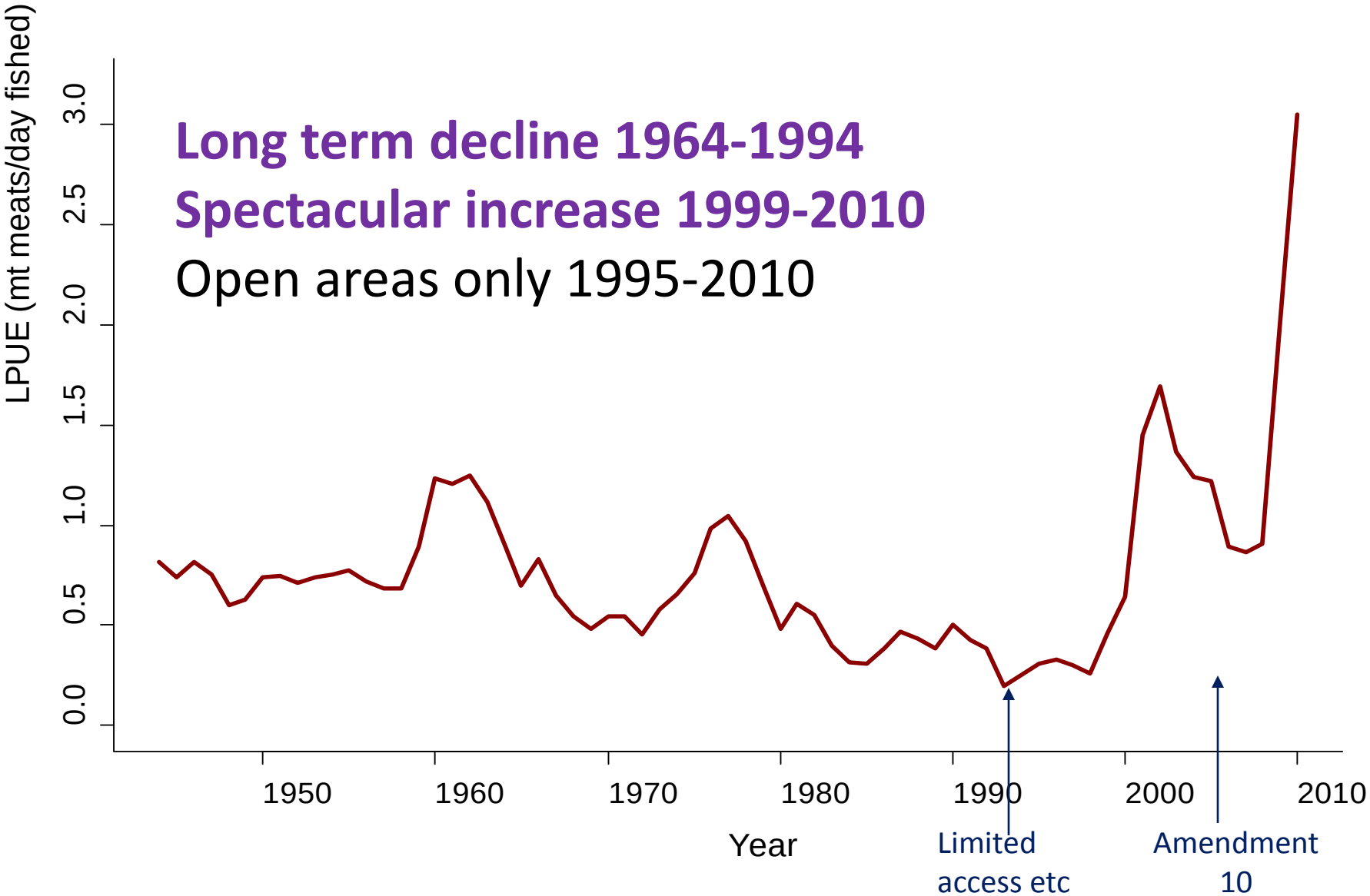
Fishery changed from open access to limited access. Each permitted vessel was given a fixed number of days to fish. Crew size on vessels was restricted, usually to 7 men

Gear restrictions gradually increased ring size from 3” to 4”

Three large areas on or near Georges Bank were closed indefinitely to fishing to help rebuild groundfish and scallops.

System of rotational area management gradually developed. Formal area management system implemented in Amendment 10 (2004), which also ended overfishing

Catch per day fished (approximately proportion to exploitable biomass) U.S. Georges Bank, 1944-2010



2011 Sea scallop fishery

Ex-vessel value of about $580 million – most valuable fishery in the US

Landings over 3 times that in 1994 with less environmental impact

Area management of fishery heavily dependent on survey data (including area specific cooperative RSA surveys)

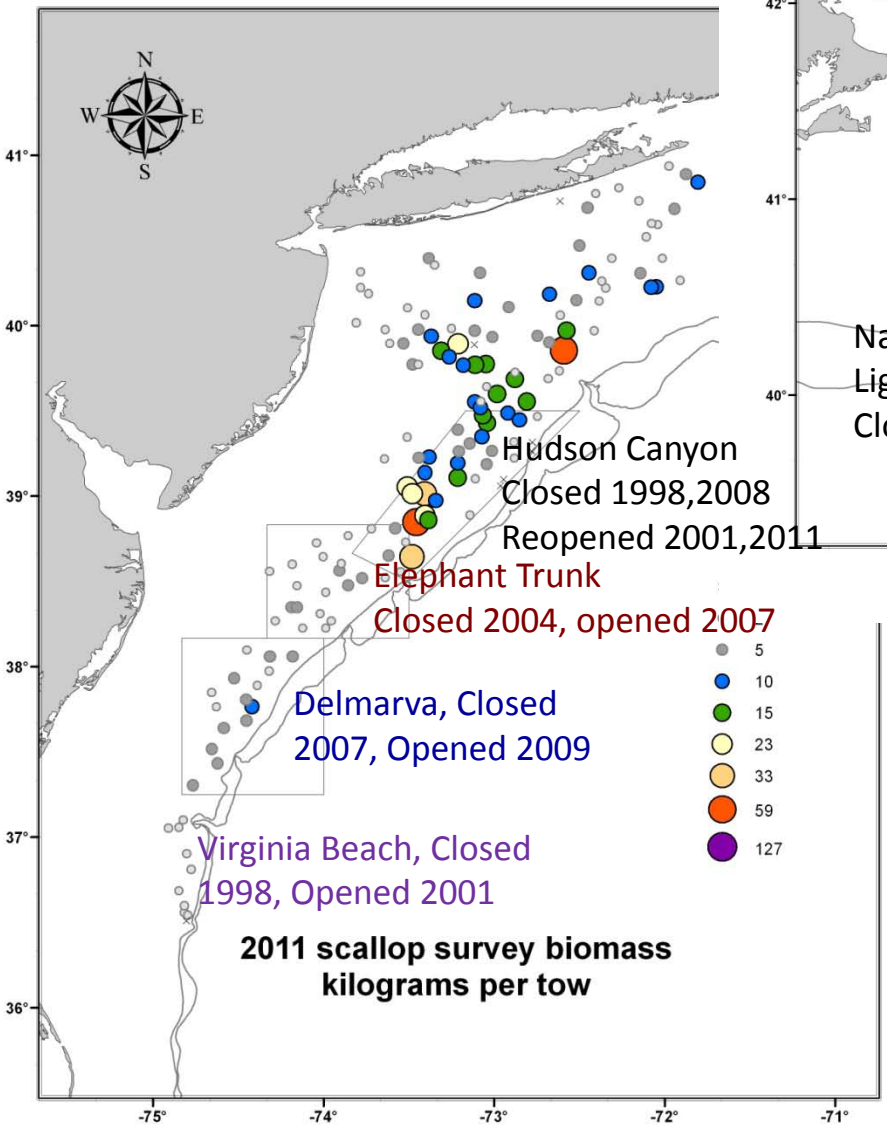
NEFSC sea scallop dredge survey

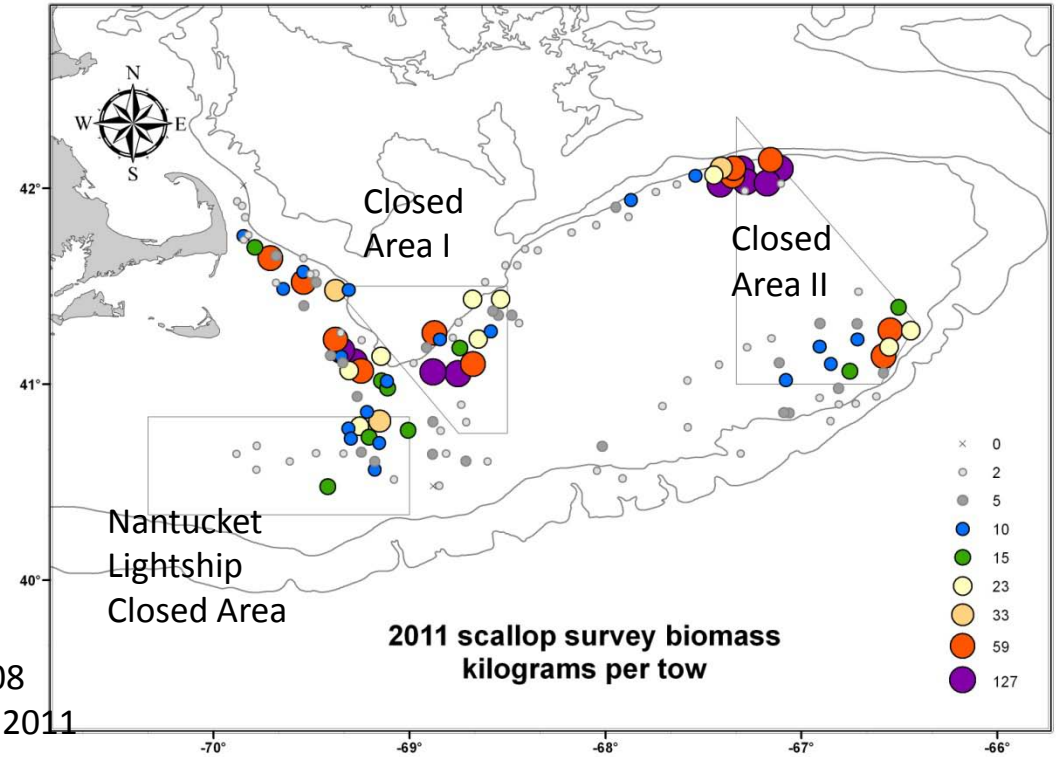
Conducted annually since 1979

Uses modified scallop fishing gear, with small 2” rings and 1.5” liner to retain small scallops

400-500 stations annually over a ~17,000 nm^2 area, using a random stratified design

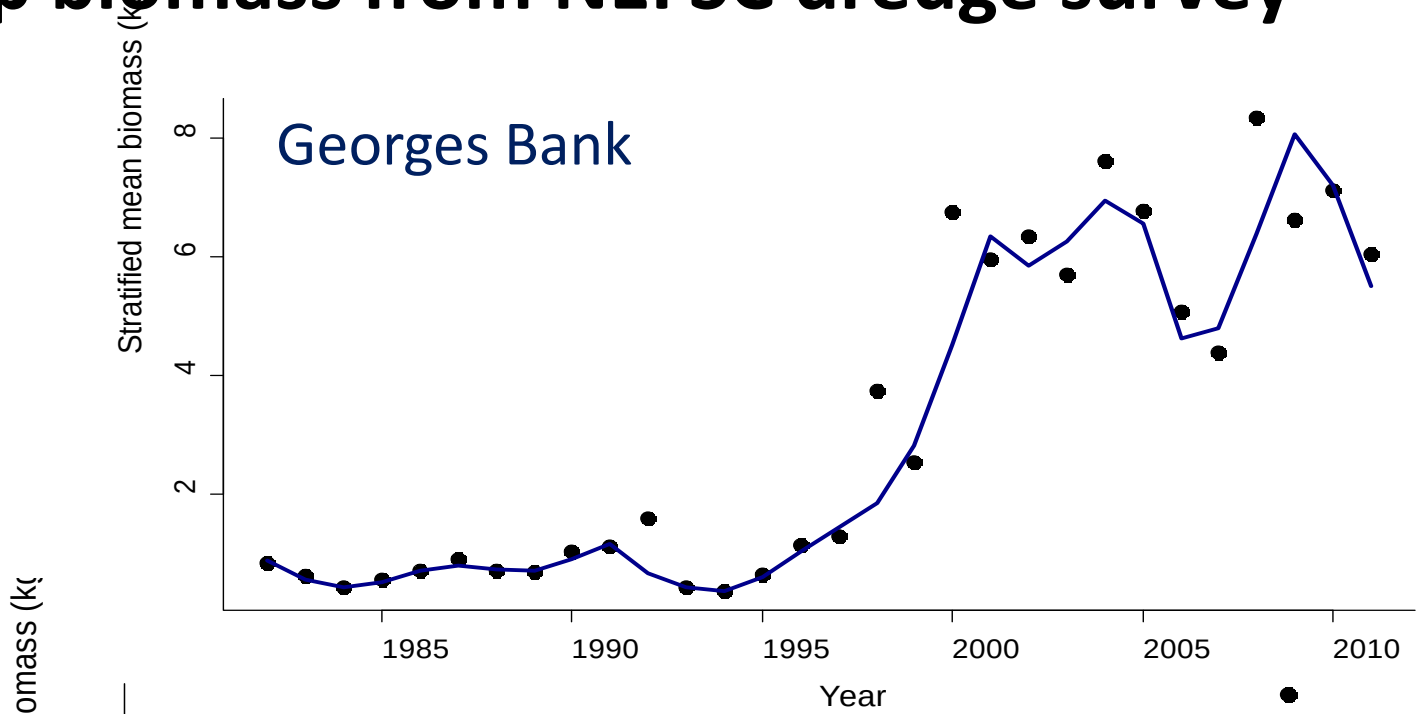
2011 dredge survey biomass charts

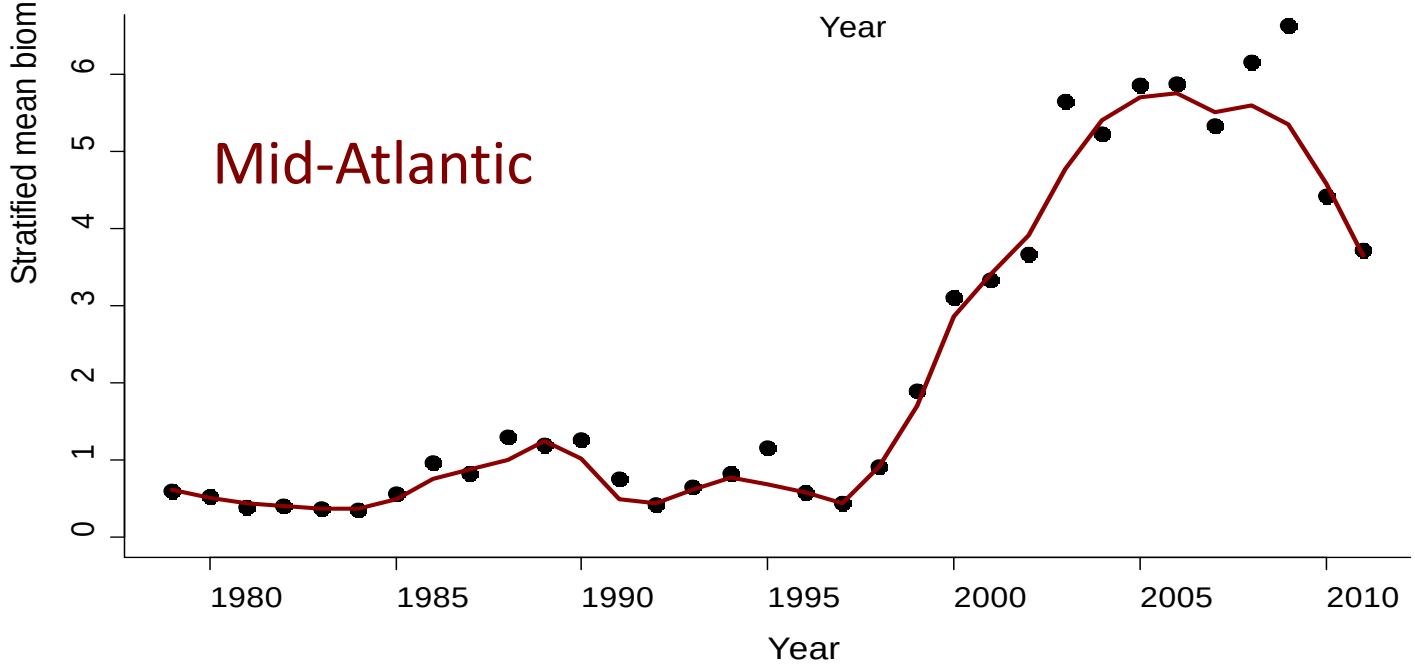


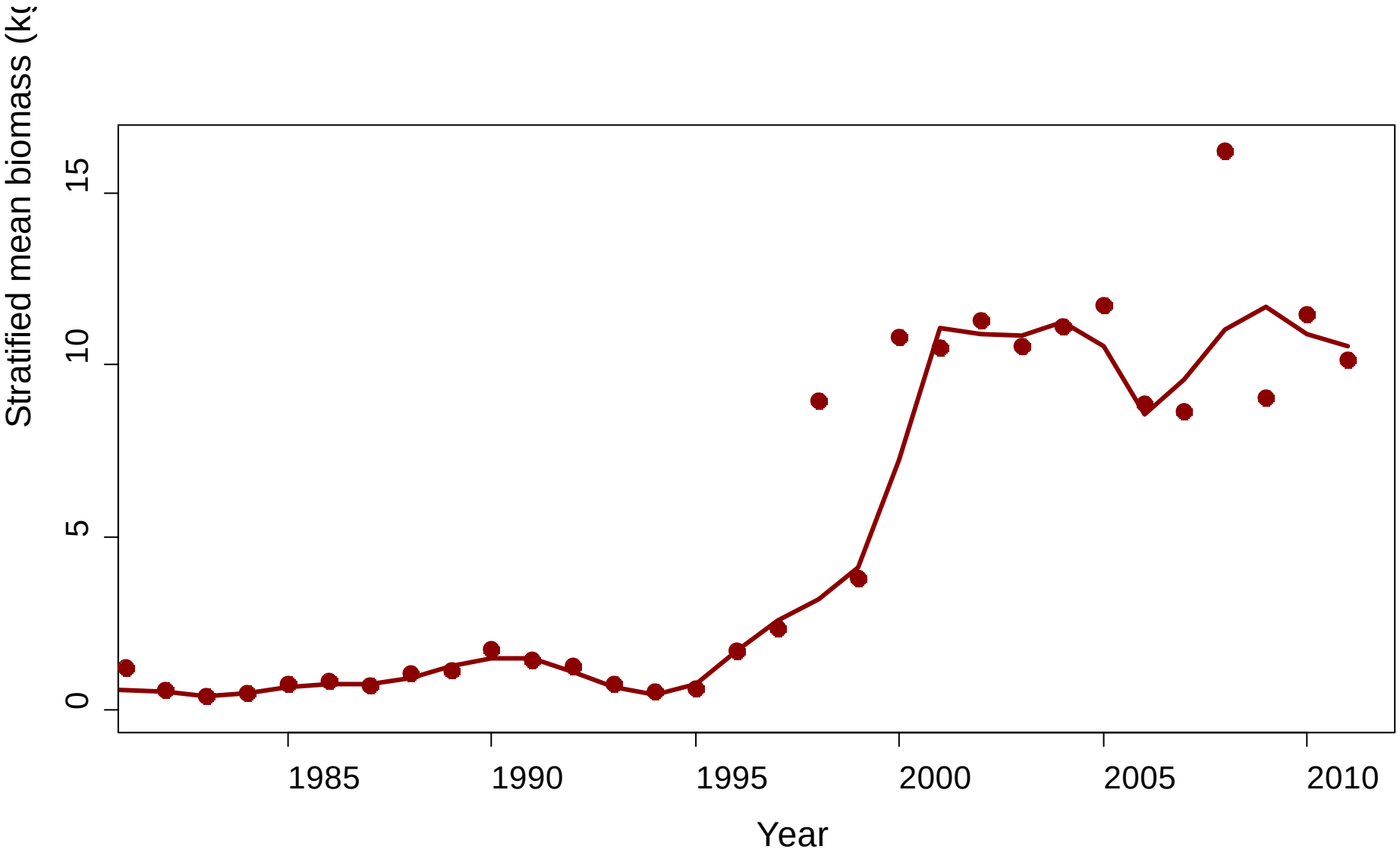


Scallop biomass from NEFSC dredge survey

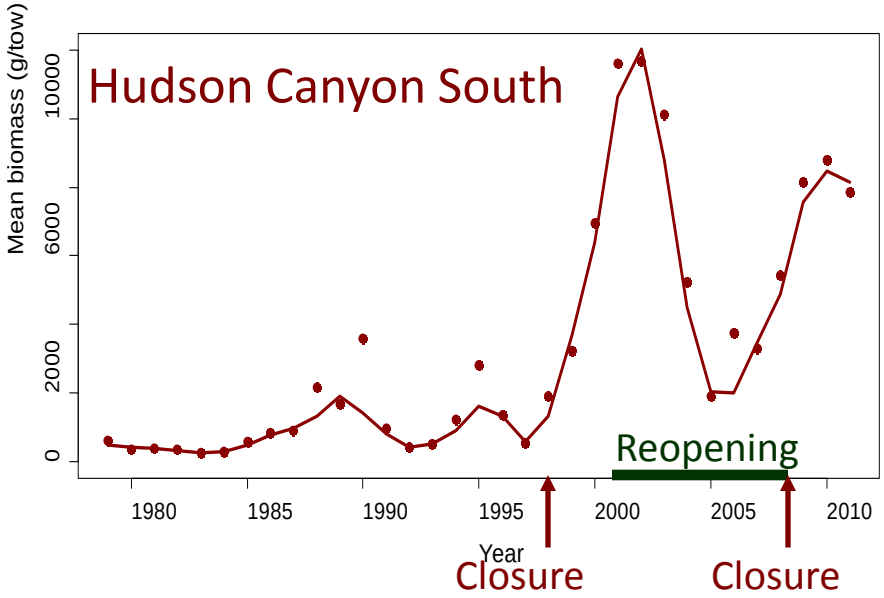
Long time series documents increases in biomass as a result of management changes starting in 1994

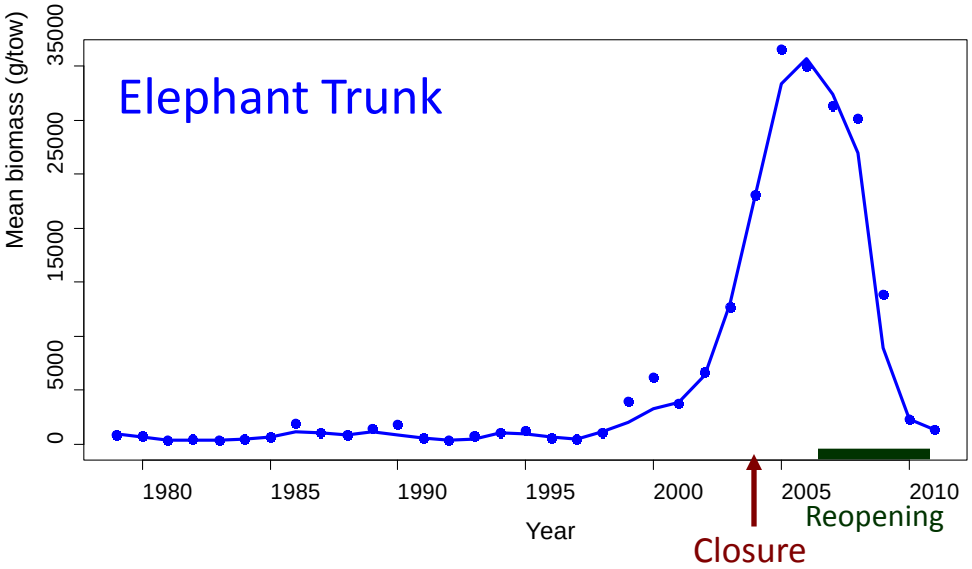


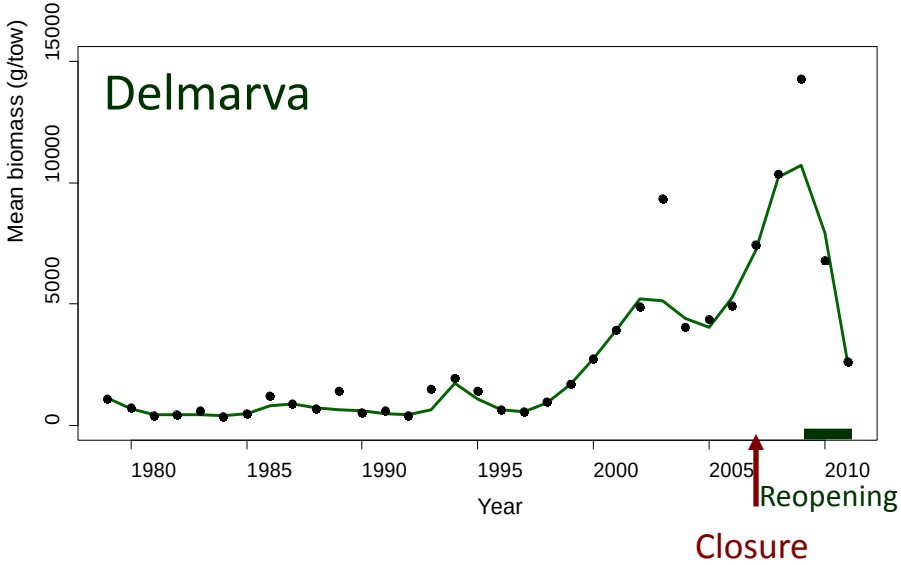


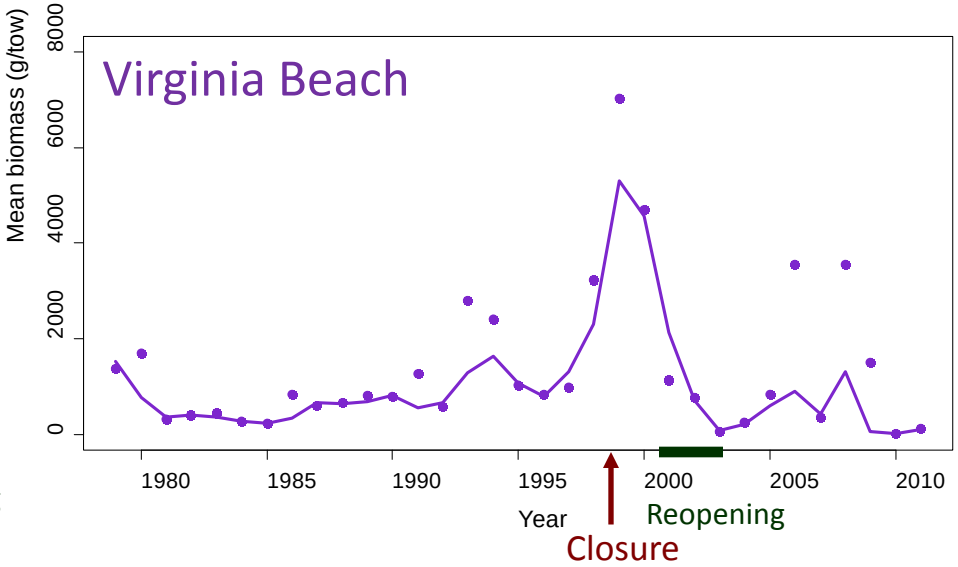

Stratified mean biomass (k
0
5
10
15
1985
1990
1995
2000
2005
2010
Year

Biomasses in Mid-Atlantic Rotational Areas









The dredge survey is labor intensive, especially since the recent increases in abundance

Dredge catches give some information on bottom type and “habitat”, but quantifying this is difficult

NEFSC scallop dredge survey

Advantages

Long time series – has contributed to successful assessment and management

Gives reasonably accurate index of abundance

Obtains physical samples for ageing, meat weights, accurate shell height measurements

Disadvantages

Labor intensive, especially as abundance has increased

Dredge efficiency less than 100%, maybe variable

Reflects average conditions along tow path – no finer scale information

No in situ information

Goals for a next generation survey

Increased accuracy of sea scallop abundance and distribution to support successful single species management

Improved understanding of the roles and distributions of benthic organisms and benthic ecosystems

Improved understanding of the relationships between fish distributions and habitat and the benthos

Video drop camera survey (SMAST)

Grid design, 4 drops per station, stations 3 nm apart

Main camera gives view of ~2.8 m^2

Video drop camera survey

Advantages

Detection efficiency approaches 100%

In situ habitat data

Gives fine scale information

Disadvantages

Limited area covered (12 m^2/station compared to 4500 m^2/station for dredge survey)

Limited number of scallops observed and measured

Shell height measurements have error

No physical samples

Fine scale (2.8 m^2) but no mesoscale information (typically 5.5 km between stations)

Habcam towed camera system

Developed by collaboration between fishermen and scientists at the Woods Hole Oceanographic Institution

Funded by RSA, NOAA, Northeast Consortium

Habcam towed camera system

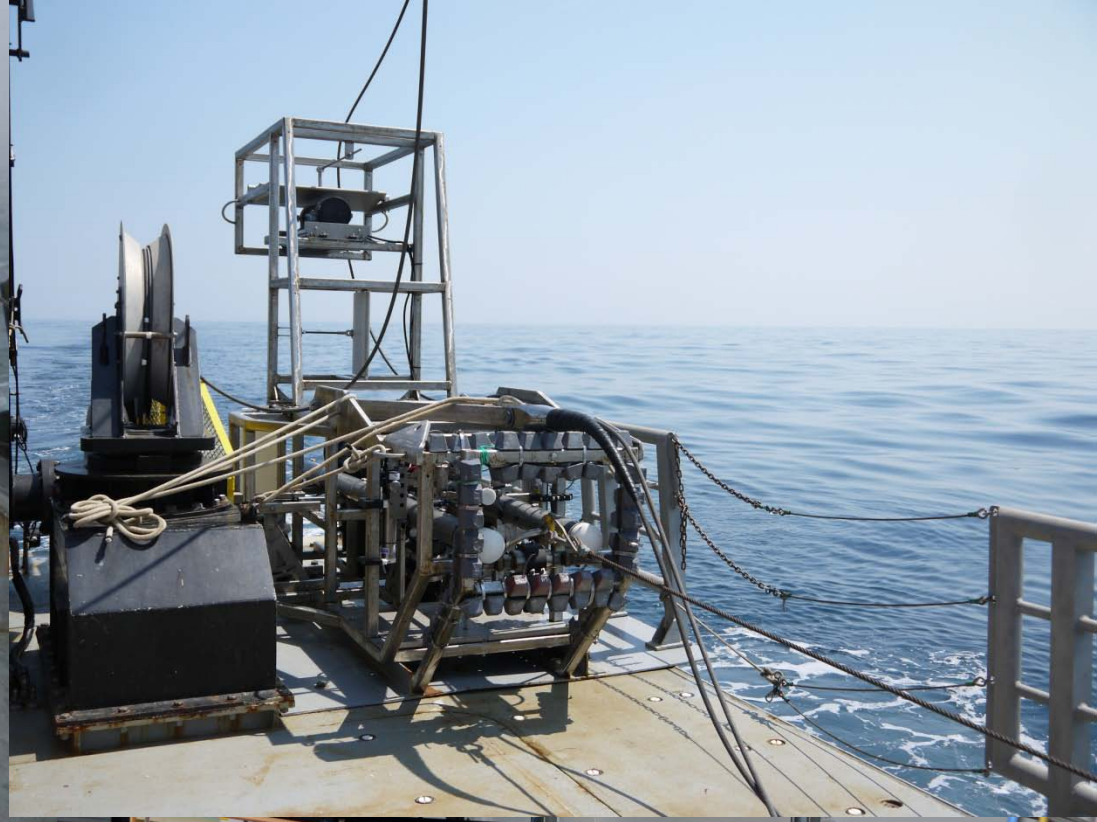
Towed at 5-6 knots about 2 m above sea bottom

Collects overlapping digital still images (>3/sec)

Images cover more area per unit time than the dredge survey, ~1000 times greater than drop camera survey

Information collected on all scales

Collects in situ information on fish and habitat
Detection efficiency approaches 100%



Camera, strobes, other instruments inside a steel frame

Vehicle towed about 2 m off the bottom

2011: Habcam survey of Georges Bank

First large-scale Habcam survey

Intended as a prototype of future surveys

Used 2005 model (v2) Habcam system

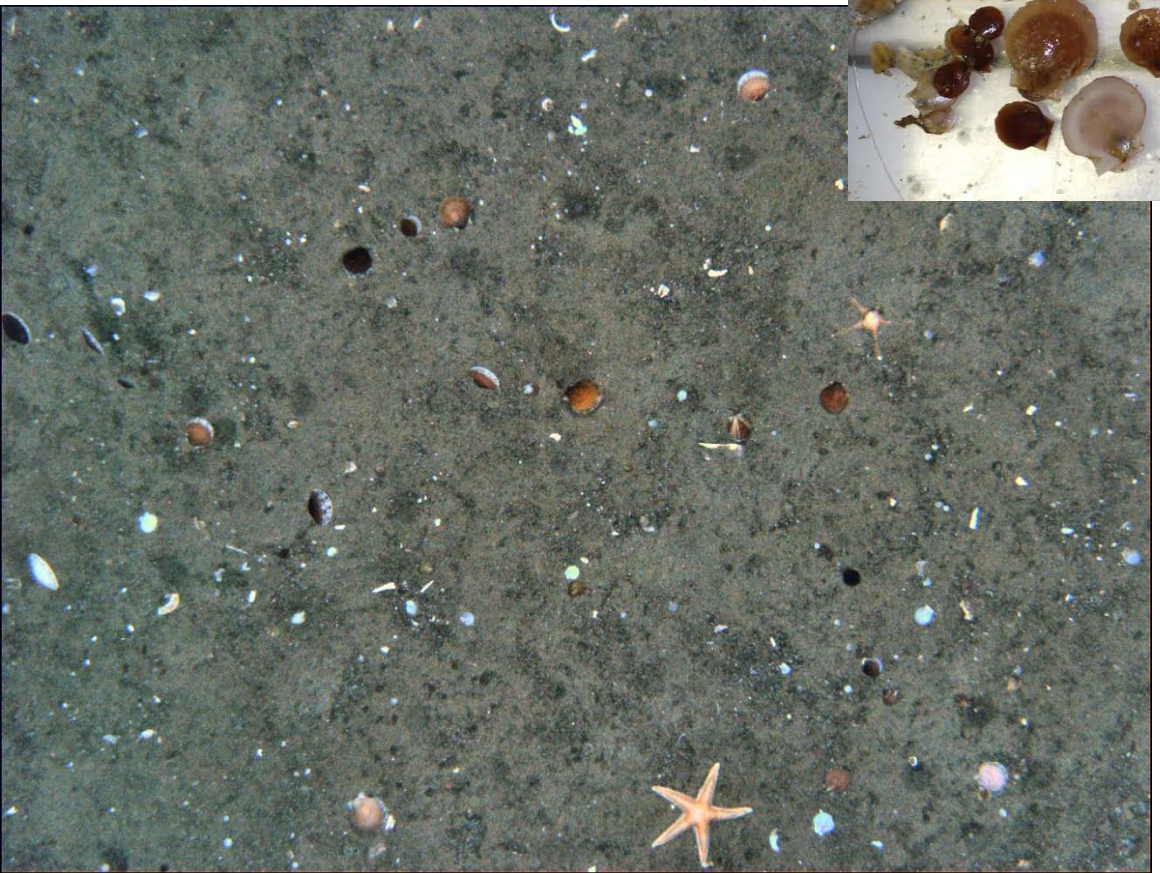
Collected about 2.5 million images in 8 sea days

2012: Combined Habcam/dredge survey of Georges Bank and Mid-Atlantic

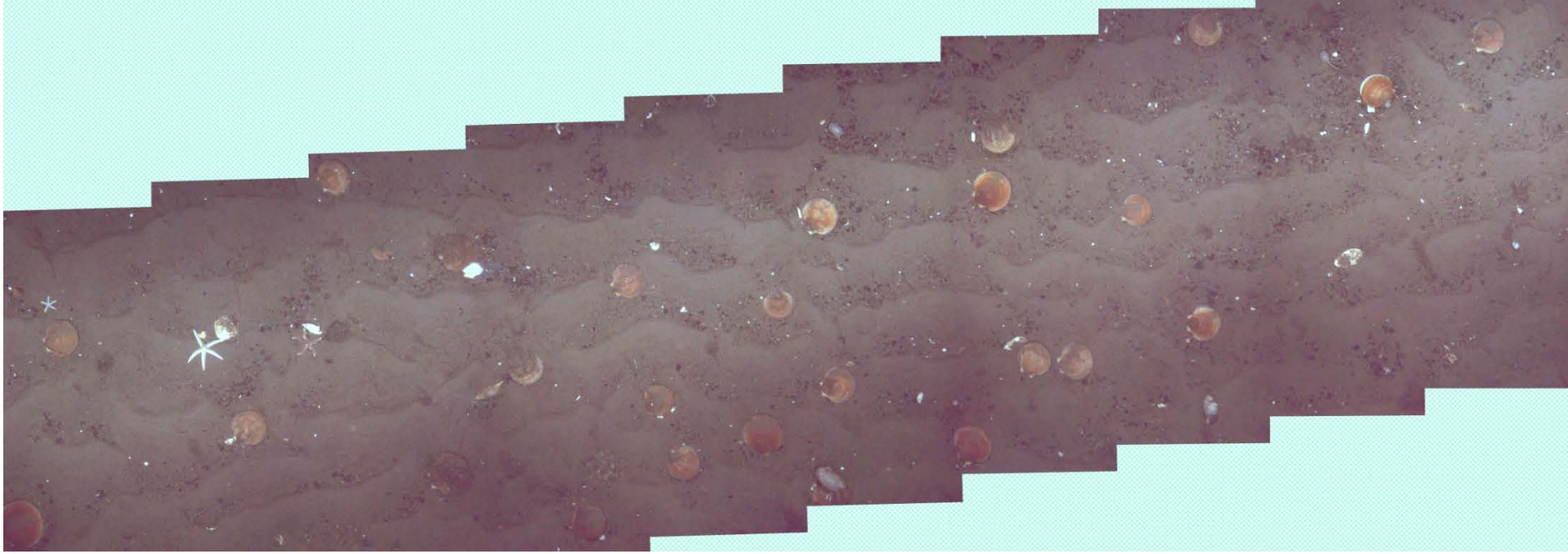
First leg completed June 12

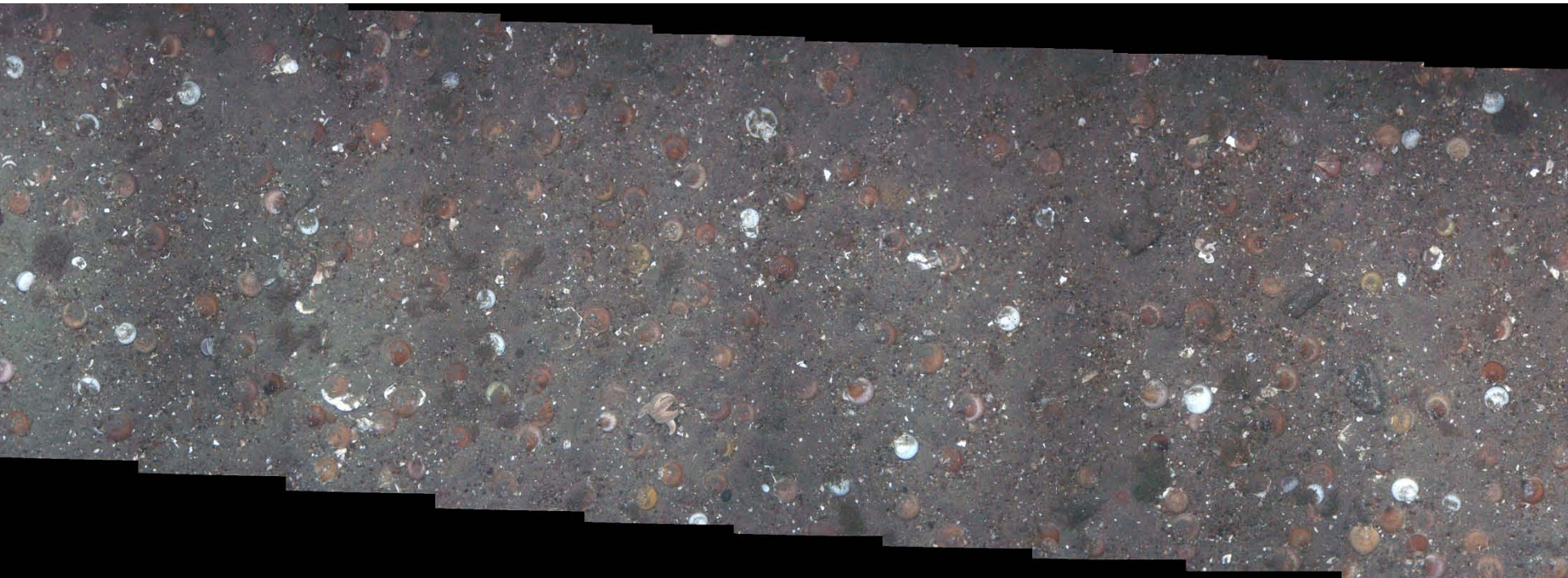
Using new NOAA (v4) Habcam system with stereo cameras and enhanced instrument package

Scallop recruitment event in the Mid-Atlantic from dredge samples 2012

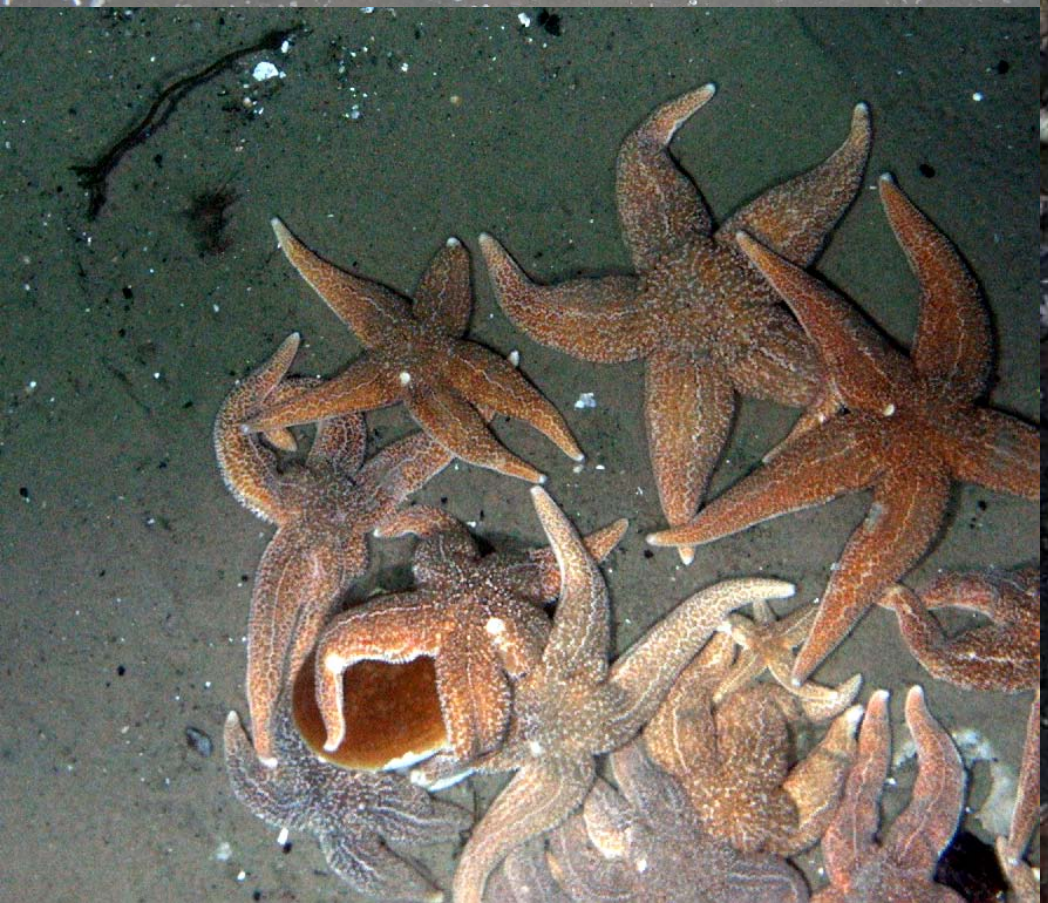


Scallop recruitment event in the Mid-Atlantic from Habcam photos

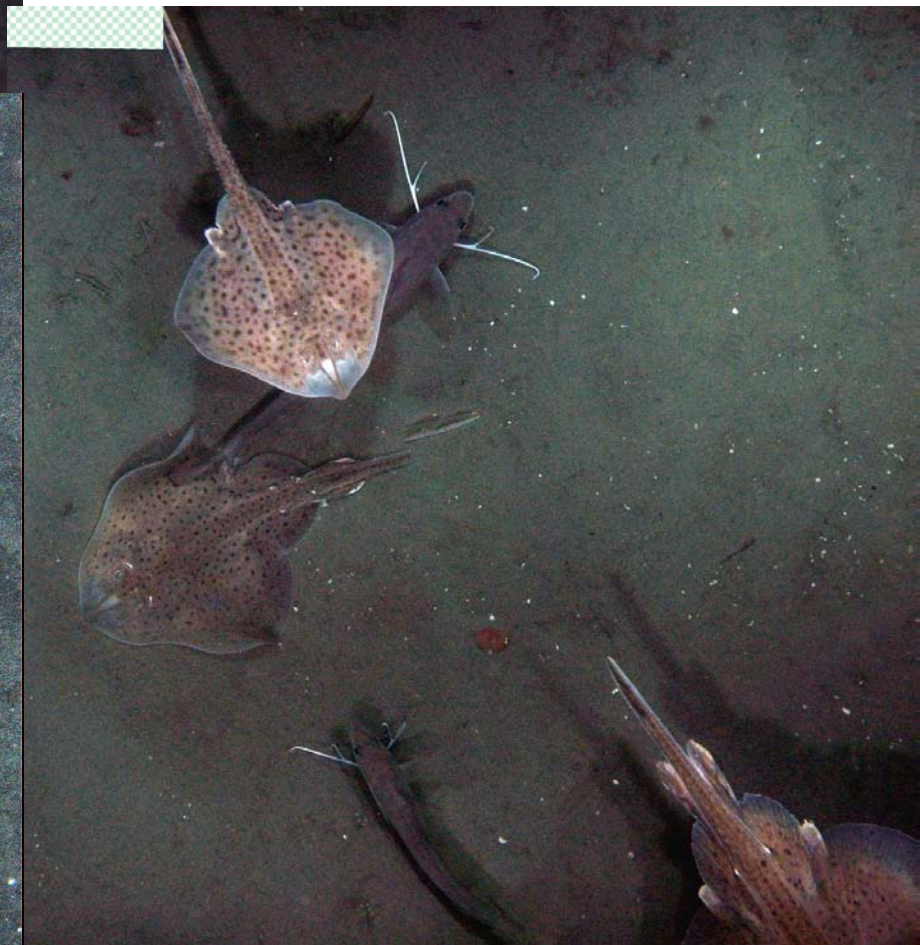




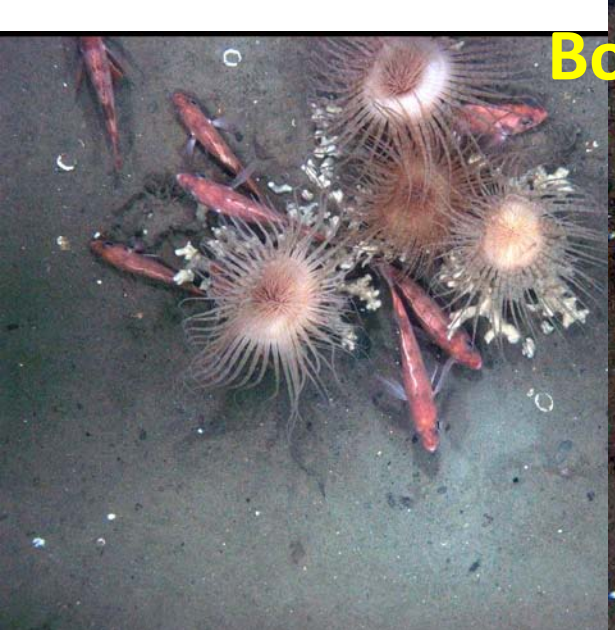
Predator-prey interactions

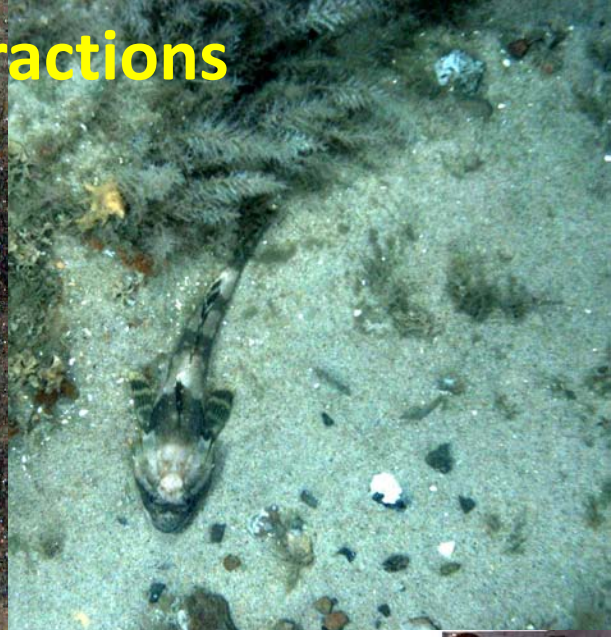


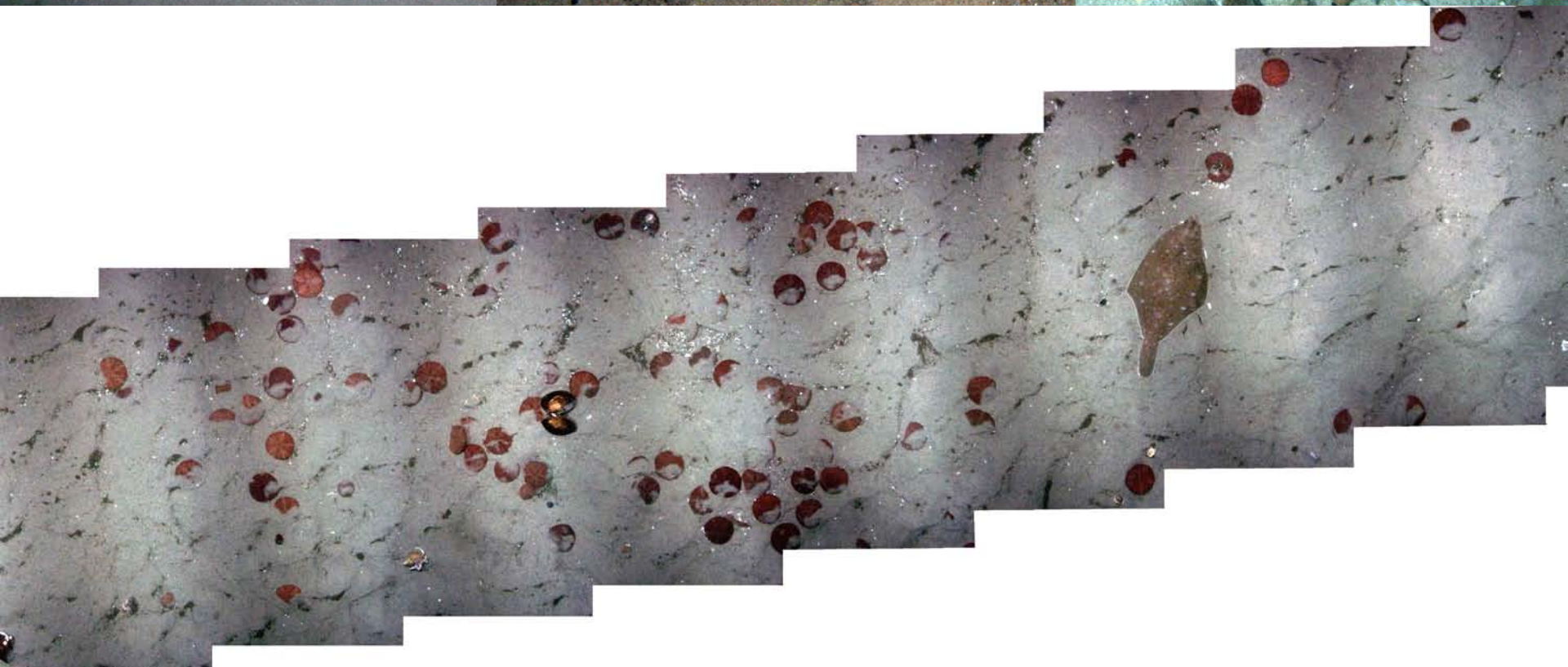
Other interactions

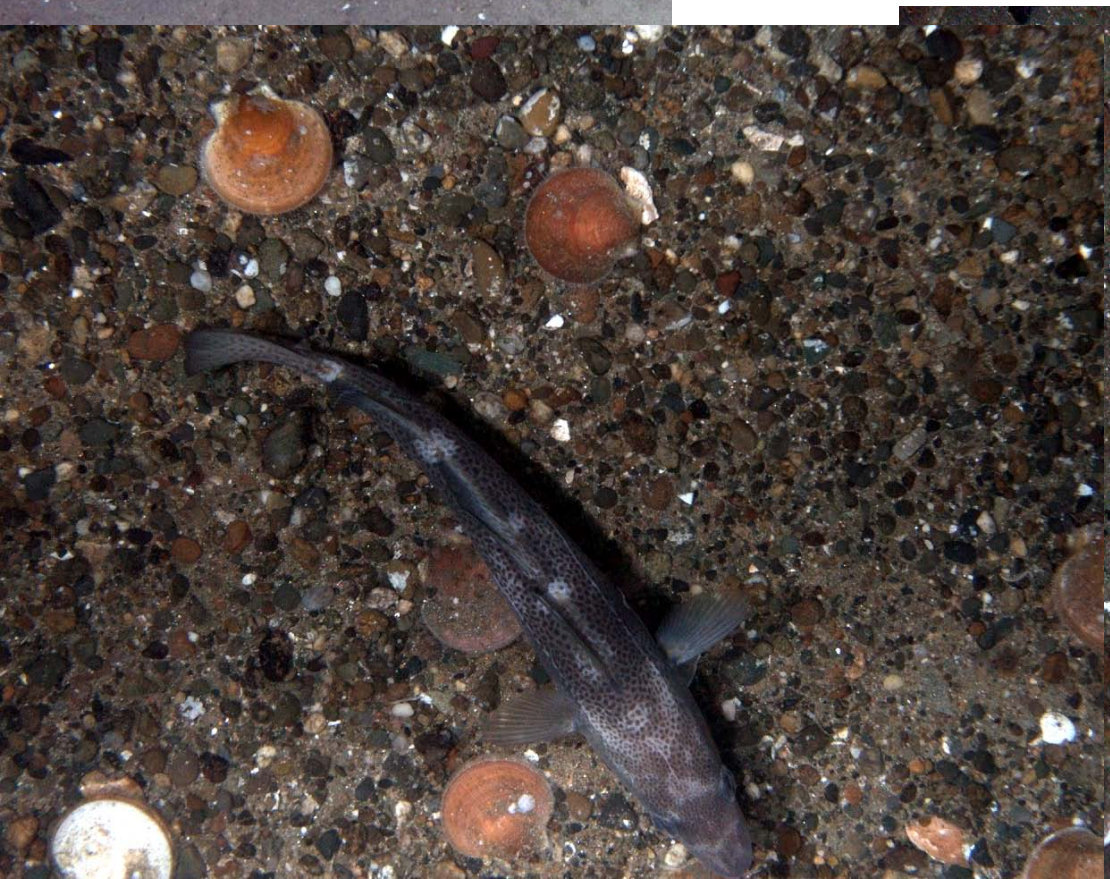


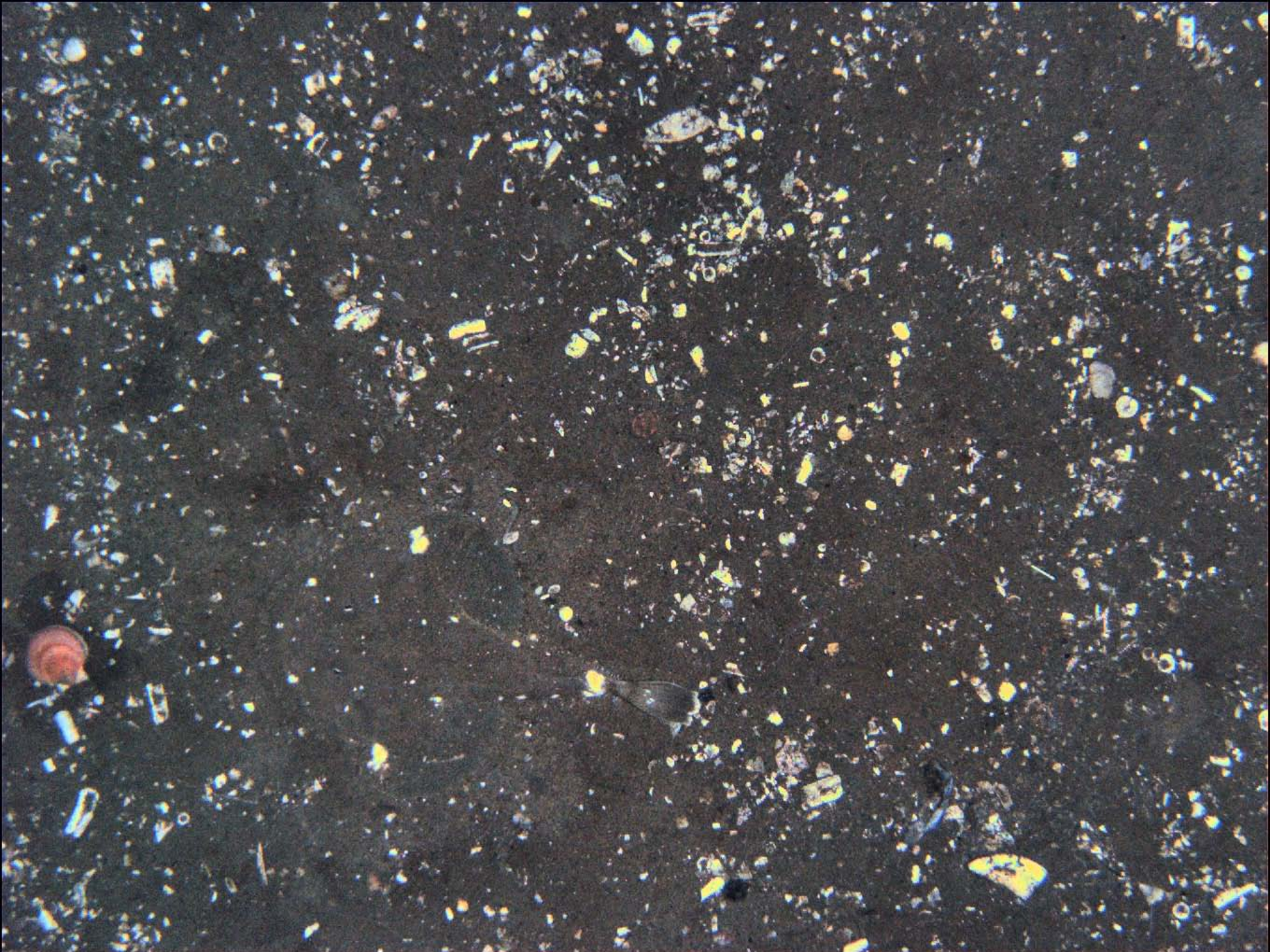
Bottom habitat and interactions

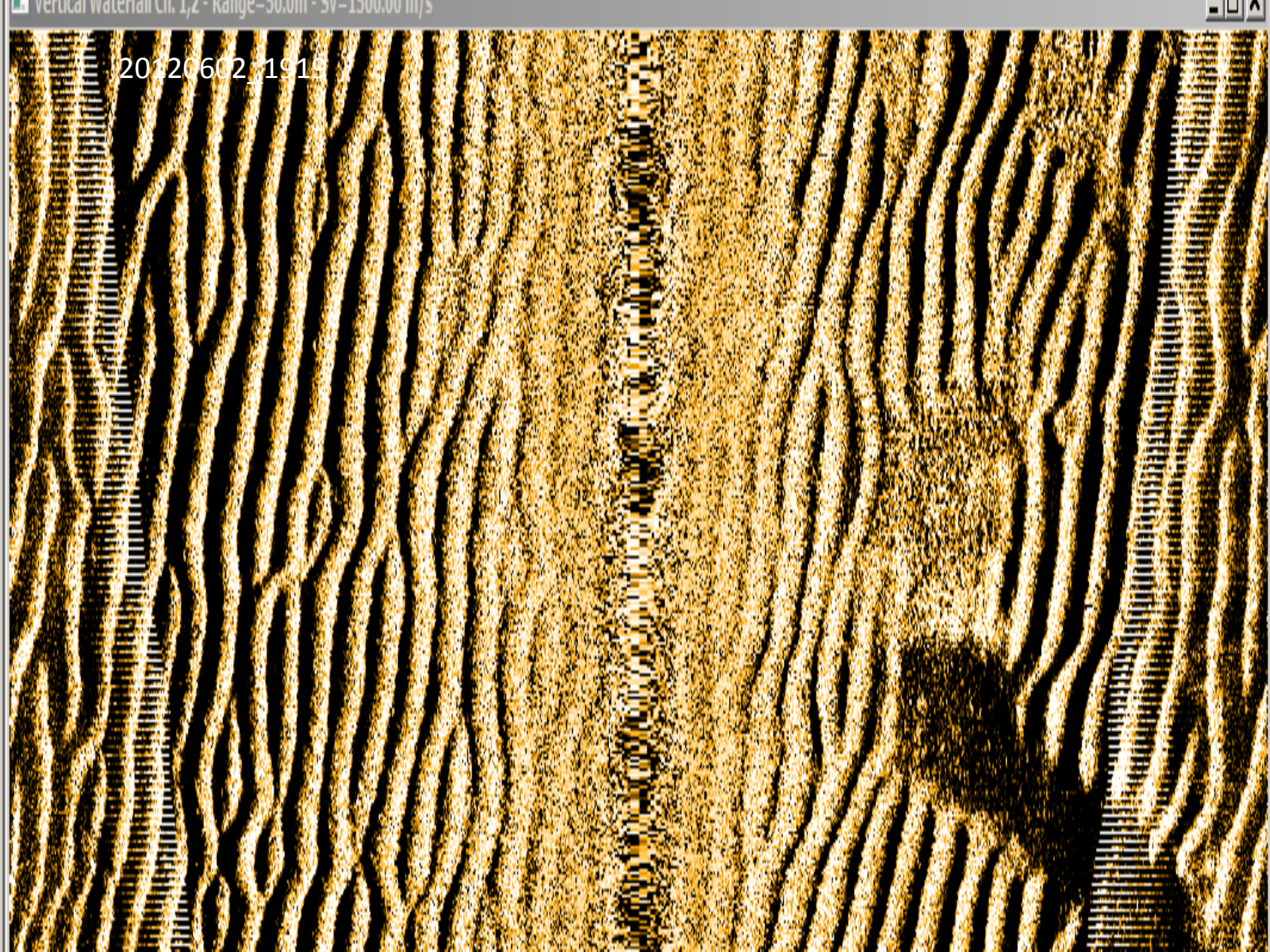


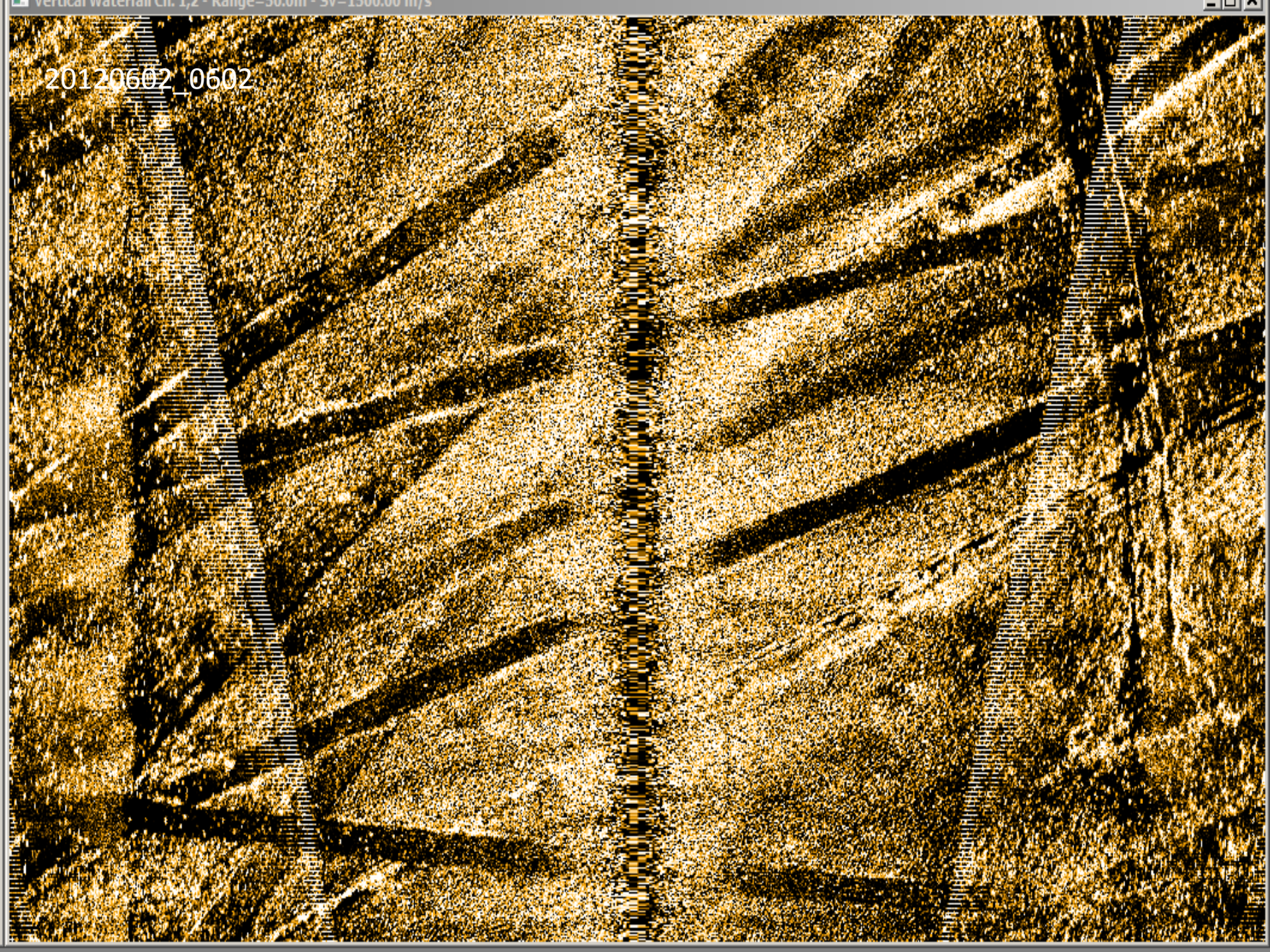









Vertical Waterfall Ch. 1,2 - Range=50.0m - Sv=1500.00 m/s
20120602_1919


Vertical Waterfall Ch. 1,2 - Range=50.0m - Sv=1500.00 m/s
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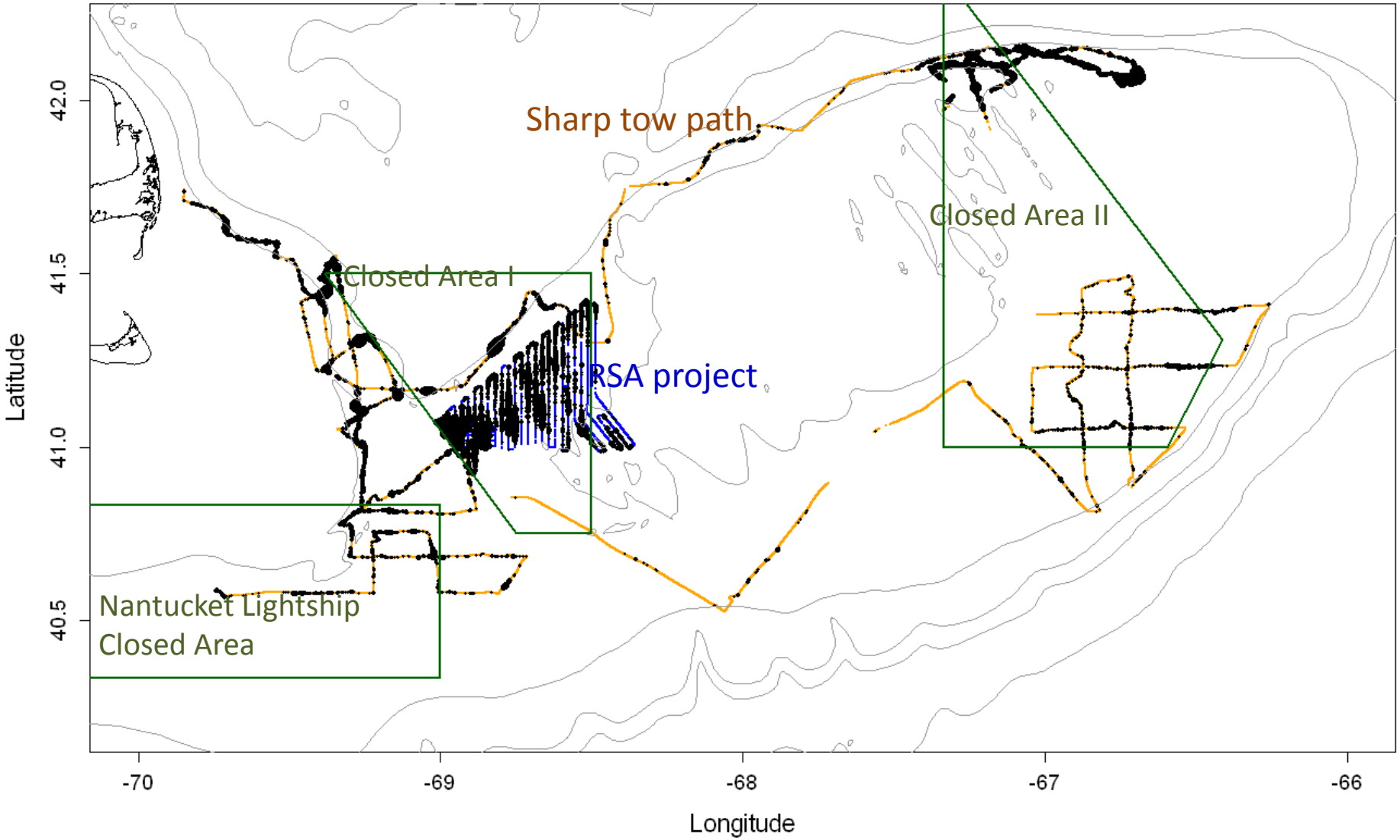
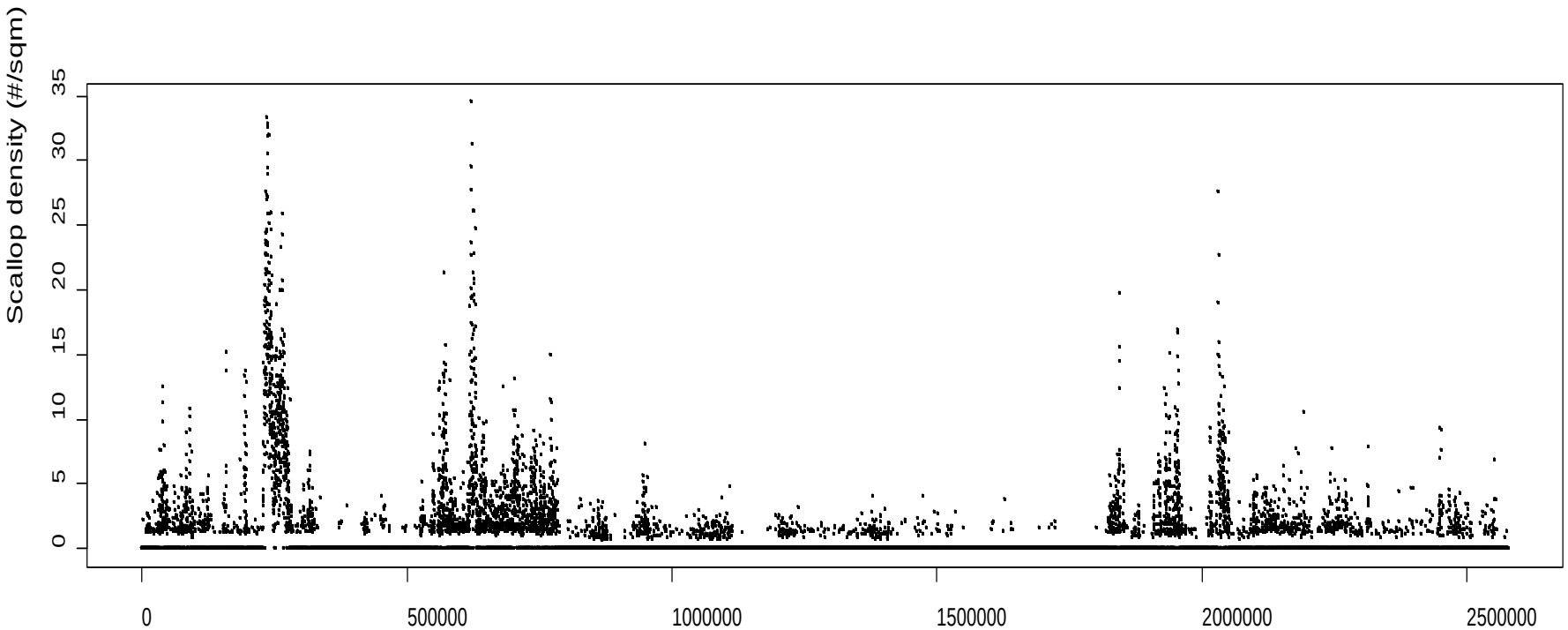
Other instruments include

Altimeter
CTD
Fluorometer (Chlorophyll)
Spectrometer (Water color)
Dissolved Oxygen

2011 – First region wide Habcam survey (Georges Bank), over 2.5 million photographs in 8 day cruise.



2011 Habcam survey of Georges Bank



South Channel (north)

CA-I (north)

CA-II (north) and Canada

CA-II (south)

Southeast Part

South Channel (south)

Nantucket Lightship Closed Area

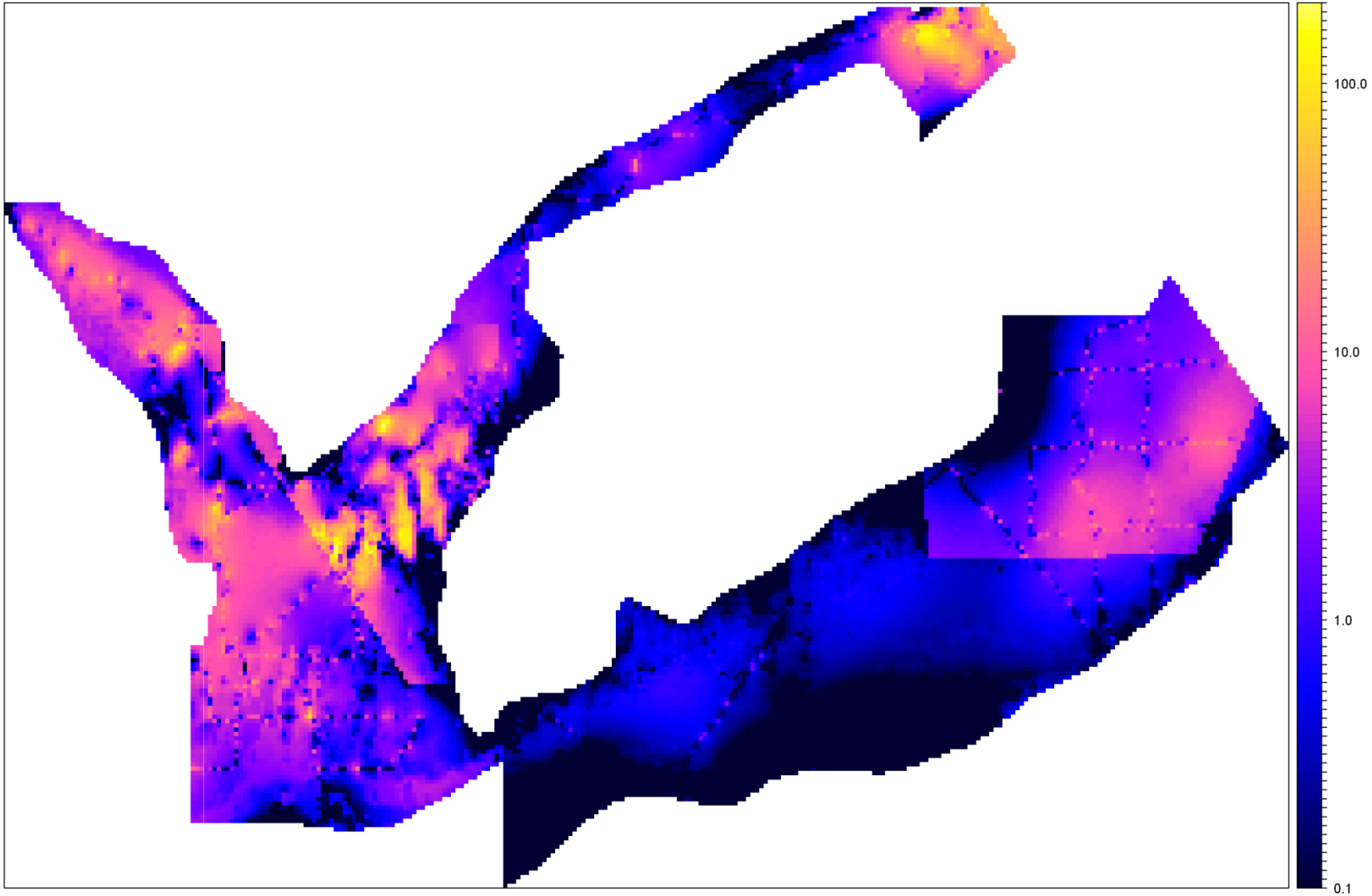
Survey analysis and abundance estimation

Requires model-based estimates (unlike random-stratified and grid surveys). Model-based inference is commonly used for predicting mineral or oil deposits, less common in fisheries

Statistical model (zero-inflated GAM) developed that estimates scallop abundance from various predictors is combined with geostatistical model

Can obtain much higher spatial resolution than any previous surveys

Predicted spatial distribution of sea scallops (metric tons of meat per square kilometer)



Comparison of survey estimates for Georges Bank (MT meats)

Area	NEFSC Dredge	SMAST	HabCam	VIMS
CL Area 1-Acc	14,833	12,582	15,024	
CL Area 1-Noacc	6,083	6,290	12,379	
CL Area 2-North	10,244	16,307	14,289	
CL Area 2-South	15,245	12,846	10,767	20,512
Nan Lightship –Acc	3,939	3,315	5,528	
Nan Lightship -Noacc	92	2,806	NS	
Northern Edge	8,028	4,715	3,024	
South Channel	17,054	26,491	26,048	
Southeast Pt	3,817	2,212	2,244	
Total	**79,335**	**87,564**	**89,303**	

Ongoing work

Automated processing of imaging progressing (work with WHOI and RPI)

Bayesian geostatistical methods – use previous surveys as informative prior

Co-kriging approaches to combining multiple surveys

Benthic habitat analysis

Habcam is a team effort

Scott Galager, Amber York (WHOI)
Richard Taylor, Norman Vine, Karen Boles

Burton Shank, Vic Nordahl, Geoff Shook, Nicole Charriere, Tim Miller, Russ Brown (NEFSC)