Multibeam Requirements for Fisheries Management

William Michaels[1] (*presenter*), Mark Amend[2], Andrew David[3], David Demer[2], Scott Ferguson[4], Guy Fleischer[5], Christopher Gledhill[2], Jon Heifetz[6], Larry Hufnagle[5], Michael Jech[1], Bob McConnaughey[6], Joyce Miller[4], Ward Testa[6], Waldo Wakefield[5], Mary Yoklavich[2]

[1]Northeast Fisheries Science Center
[2]Southwest Fisheries Science Center
[3]Southeast Fisheries Science Center
[4]Pacific Islands Fisheries Science Center
[5]Northwest Fisheries Science Center
[6]Alaska Fisheries Science Center

3rd Multibeam Workshop (sponsored by NMAO & NOS) in Boulder, CO during 10-12 March 2004

Multibeam Requirements in support of NOAA's FY03-FY08 Strategic Plan

Mission 1: "Protect, restore, and manage the use of coastal and oceanic resources through ecosystem-based management"

- *watercolumn & seafloor multibeam to improve research for fisheries management, habitat conservation, & protecting endangered species*

Mission 2: "Understand climate variability and change to enhance society's ability to plan and respond"

- *watercolumn & seafloor multibeam to monitor anthropogenic & climatic effects on living marine resources & ecosystem*

Mission 3: "Serve society's needs for weather and water information"

Mission 4: "Support the nation's commerce with information for safe, efficient, and environmentally sound transportation"

- *seafloor multibeam for bathymetric and navigational mapping*

"Cross-cutting" goal: "State-of-the-art Research"

- *multibeam is an important "cross-cutting" advanced technology*

Multibeam Requirements for NMAO's Strategic Plan

"NOAA Marine and Aviation Operations operates a wide variety of specialized aircraft and ships to complete NOAA's environmental and scientific missions"

&

"NOAA's ship fleet provides hydrographic survey, oceanographic and atmospheric research, and fisheries research vessels to support NOAA's strategic plan elements and mission".

Seafloor and watercolumn multibeam aboard NOAA vessels supports NOAA's Mission Goals 1, 2, 4, and NOAA's "Cross-cutting" Priority "State-of-the-art Research"

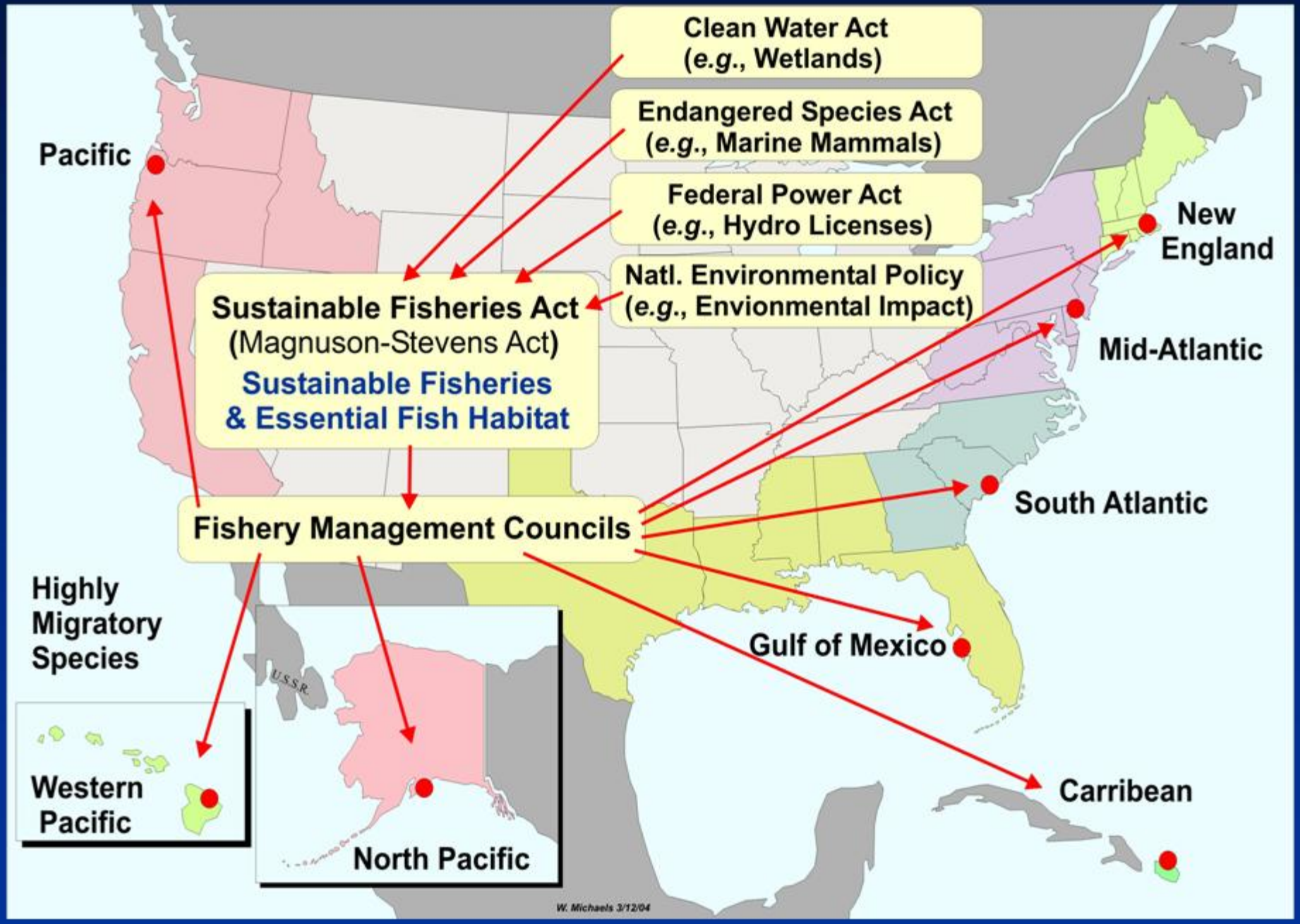
Multibeam Requirements for NMFS's Strategic Plan

"Optimal stewardship of living marine resources through science-based conservation and management, and the promotion of healthy ecosystems".

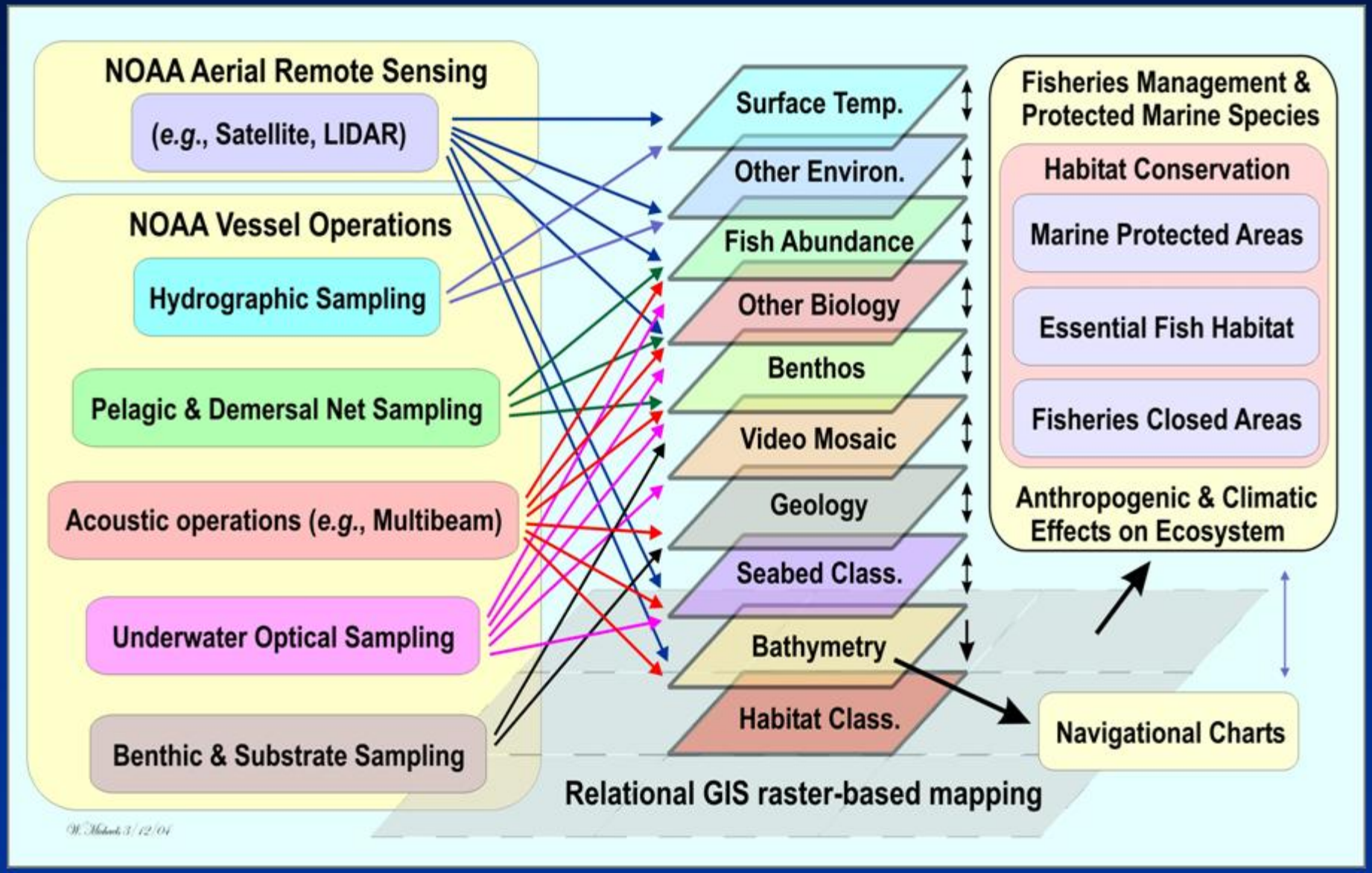
Sustained Fisheries Management
Marine Species Protection
Marine Habitat Conservation
Ecosystem Research
Science & Technology

Synoptic watercolumn & seafloor multibeam will provide more cost-effective, accurate, & timely research products in support of NMFS's Strategic Plan & mandated responsibilities

NOAA Mandates for Sustainable Fisheries & Essential Fish Habitat



Synoptic Watercolumn & Seafloor Multibeam Operations Provide Input for Integrated Products in Support of Fisheries Management



Products from Multibeam

(1). Seafloor IHO mapping – IHO seafloor mapping for navigational charts (IHO is desired for fisheries & habitat multibeam research)

(2). High resolution bathymetry – bathymetric mapping (1-10 m resolution for habitat mapping and <1 m for gear effects)

(3). Seabed classification – acoustic response of seafloor backscatter that characterizes physical, geological, & biological features

(4). Watercolumn backscatter – watercolumn backscatter for density-distribution maps & spatial variability of biological assemblages

(5). Watercolumn population estimates – quantitative watercolumn backscatter for population estimates (Research & Development is underway)

Sustained Fisheries Management

Research / Multibeam Products	High Resolution Bathymetry	Seabed Classification	Watercolumn Backscatter	Watercolumn Population Est.
Stock Assessment Improvement (SAIP)	Critical O	Critical O	Required O	Critical R&D
Multispecies stock assessment	Desired O	Desired O	Required O	Required R&D
Vessel noise & sampling effects	Desired O	Desired O	Critical O	Required R&D
Spatial variability of estimates	Required O	Required O	Required O	Required R&D
Survey strata delineation	Required O	Required O	Critical O	Critical R&D

Critical = *Required & research is underway*
Required = *Required & multibeam is unavailable*
Desired = *Desired & multibeam is unavailable*
O = *Operational if available*
R&D = *Research & Development required*

Protected Marine Species

Research / Multibeam Products	High Resolution Bathymetry	Seabed Classification	Watercolumn Backscatter	Watercolumn Population Est.
Prey abundance & distribution	Desired ○	Required ○	Critical ○	Required R&D
Modeling foraging behavior	Desired ○	Required ○	Critical ○	Required R&D
ESA Critical Habitat definition	Critical ○	Critical ○	Critical ○	Required R&D
Predicting protected species distribution	Critical ○	Critical ○	Critical ○	Critical R&D

Critical = *Required & research is underway*
Required = *Required & multibeam is unavailable*
Desired = *Desired & multibeam is unavailable*
O = *Operational if available*
R&D = *Research & Development required*

Marine Habitat Conservation

Research / Multibeam Products	High Resolution Bathymetry	Seabed Classification	Watercolumn Backscatter	Watercolumn Population Est.
Marine Protected Areas (MPAs)	Critical O	Critical O	Critical O	Critical R&D
Essential Fish Habitat (EFH)	Critical O	Critical O	Critical O	Critical R&D
Fisheries Closed Areas	Required O	Required O	Critical O	Critical R&D
Gear effects	Critical R&D	Required O	Desired O	Desired R&D
Biodiversity	Required O	Required O	Required O	Desired R&D

Critical = *Required & research is underway*
Required = *Required & multibeam is unavailable*
Desired = *Desired & multibeam is unavailable*
O = *Operational if available*
R&D = *Research & Development required*

Ecosystem Research

Research / Multibeam Products	High Resolution Bathymetry	Seabed Classification	Watercolumn Backscatter	Watercolumn Population Est.
Ecosystem modeling	Desired ○	Desired ○	Required ○	Required R&D
Multispecies population dynamics	Desired ○	Desired ○	Required ○	Required R&D
Predator-prey distributions	Required ○	Required ○	Critical ○	Desired R&D
Environmental effects on ecosystem	Required ○	Required ○	Required R&D	Required R&D
Ocean observation reference sites	Desired ○	Desired ○	Required R&D	Required R&D

Critical = *Required & research is underway*
Required = *Required & multibeam is unavailable*
Desired = *Desired & multibeam is unavailable*
○ = *Operational if available*
R&D = *Research & Development required*

Science & Technology

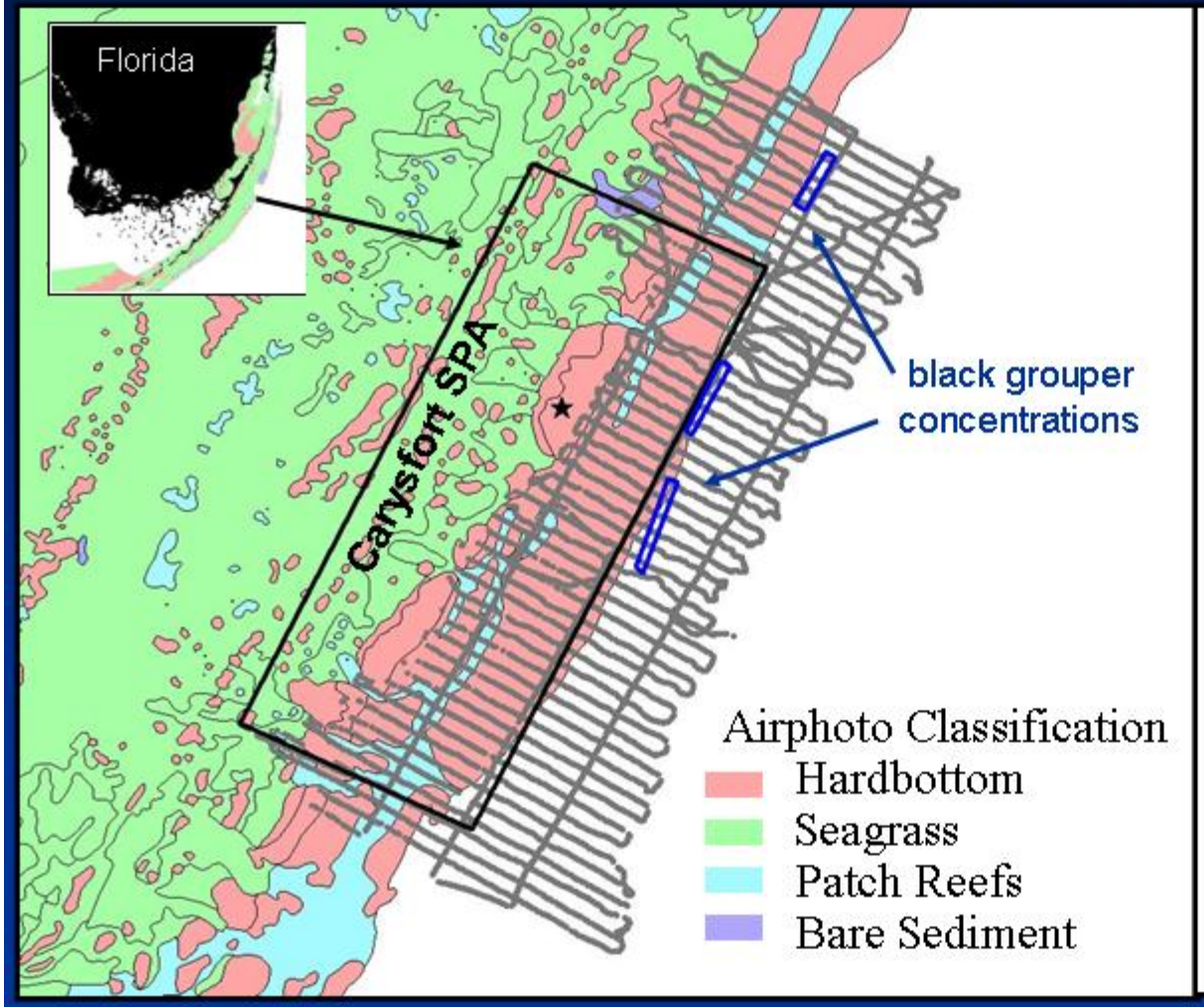
Research / Multibeam Products	High Resolution Bathymetry	Seabed Classification	Watercolumn Backscatter	Watercolumn Population Est.
Improve the sampling efficiency, accuracy, & timeliness of products	Critical ○	Required ○	Critical ○	Critical R&D
Integrate watercolumn and seafloor multibeam technologies	Critical R&D	Critical ○	Critical ○	Required R&D
Quantitative multibeam backscatter	Desired	Required ○	Critical R&D	Critical R&D
"Cross-cutting" research to improve interagency expertise & science	Critical R&D			

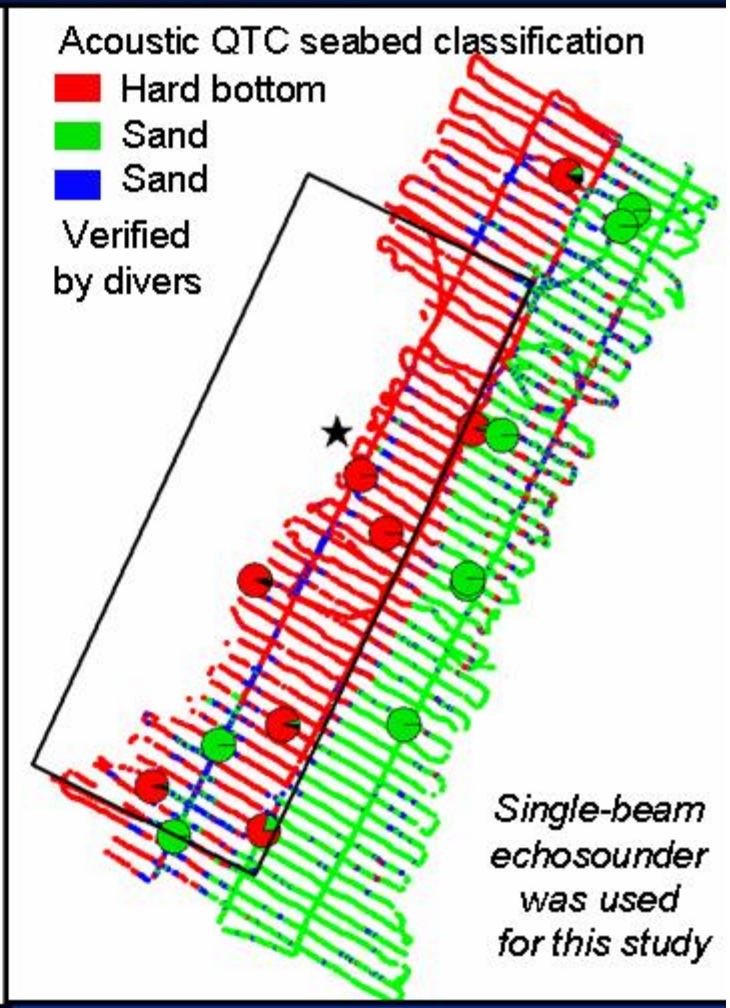
Critical = *Required to improve science (some multibeam research is underway even though it may be presently unavailable aboard NOAA vessels)*
Important = *Desired to improve science*
Useful = *Used if available*
R&D = *Research & Development required to make operational*

Example of MPA Habitat Mapping in the SEFSC Region

Multibeam seafloor & watercolumn backscatter would improve research for Marine Protected Areas (MPA) & Essential Fish Habitat (EFH)

Biological, geophysical & environmental parameters are required for marine habitat mapping to delineate & monitor EFH & MPA





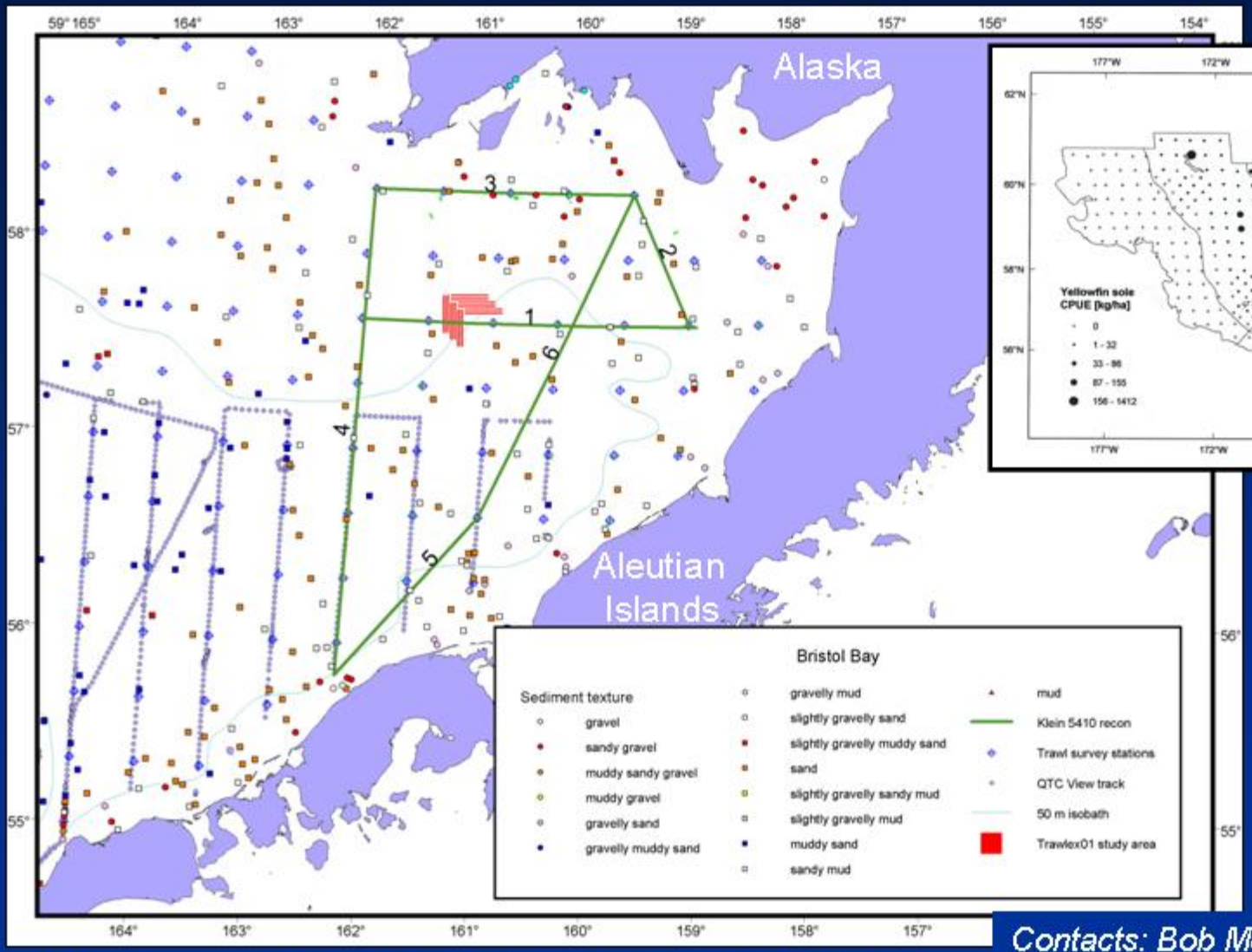
[1] *Does not imply endorsement of vendor's product*

Contacts: Art Gleason, Pamela Reid (Univ. Miami)
Anne-Marie Eklund, Veronique Koch (SEFSC)

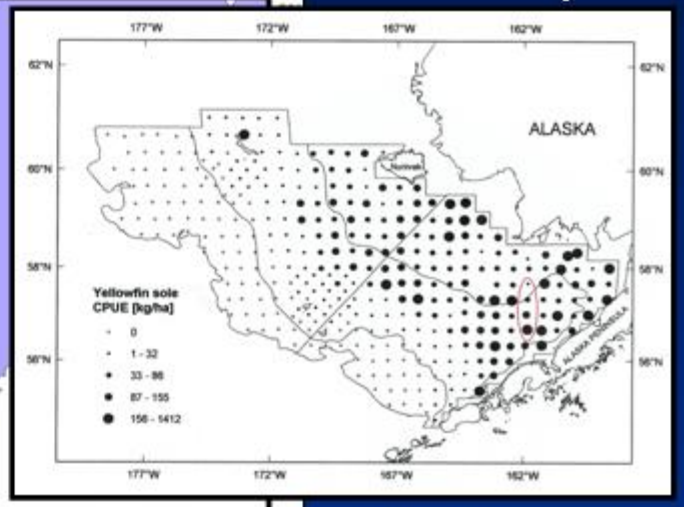
Example of Acoustic Habitat Mapping in the AFSC Region

for improving Essential Fish Habitat research & fisheries management

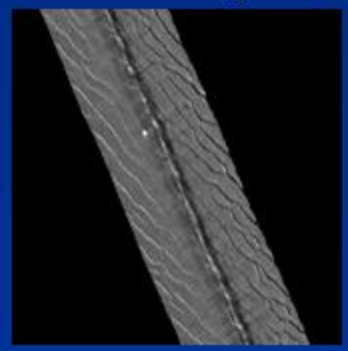
Sidescan (Klein 5410[1]) high resolution imaging (<0.1m) of seafloor surface, seabed classification & fish distributions are used in Essential Fish Habitat research



Trawl surveys



Sidescan sonar bottom images



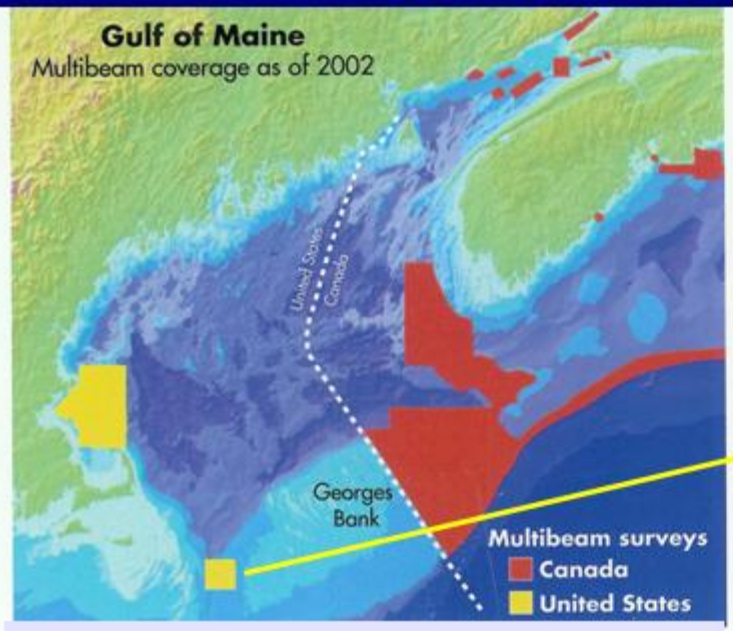
[1] Does not imply endorsement of vendor's product

Klein 5410[1] owned by AFSC & NOS

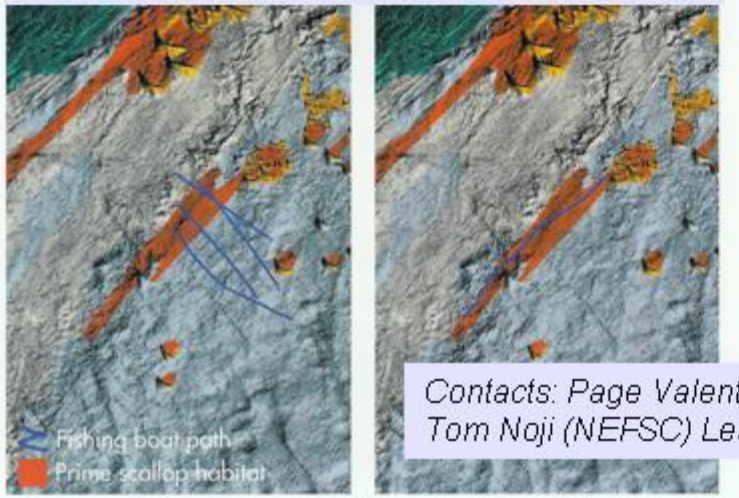
Contacts: Bob McConnaughey (AFSC)
Guy Noll (NOS) Lloyd Huff (NOAA-UNH)

Example of Multibeam Habitat Mapping in NEFSC Region

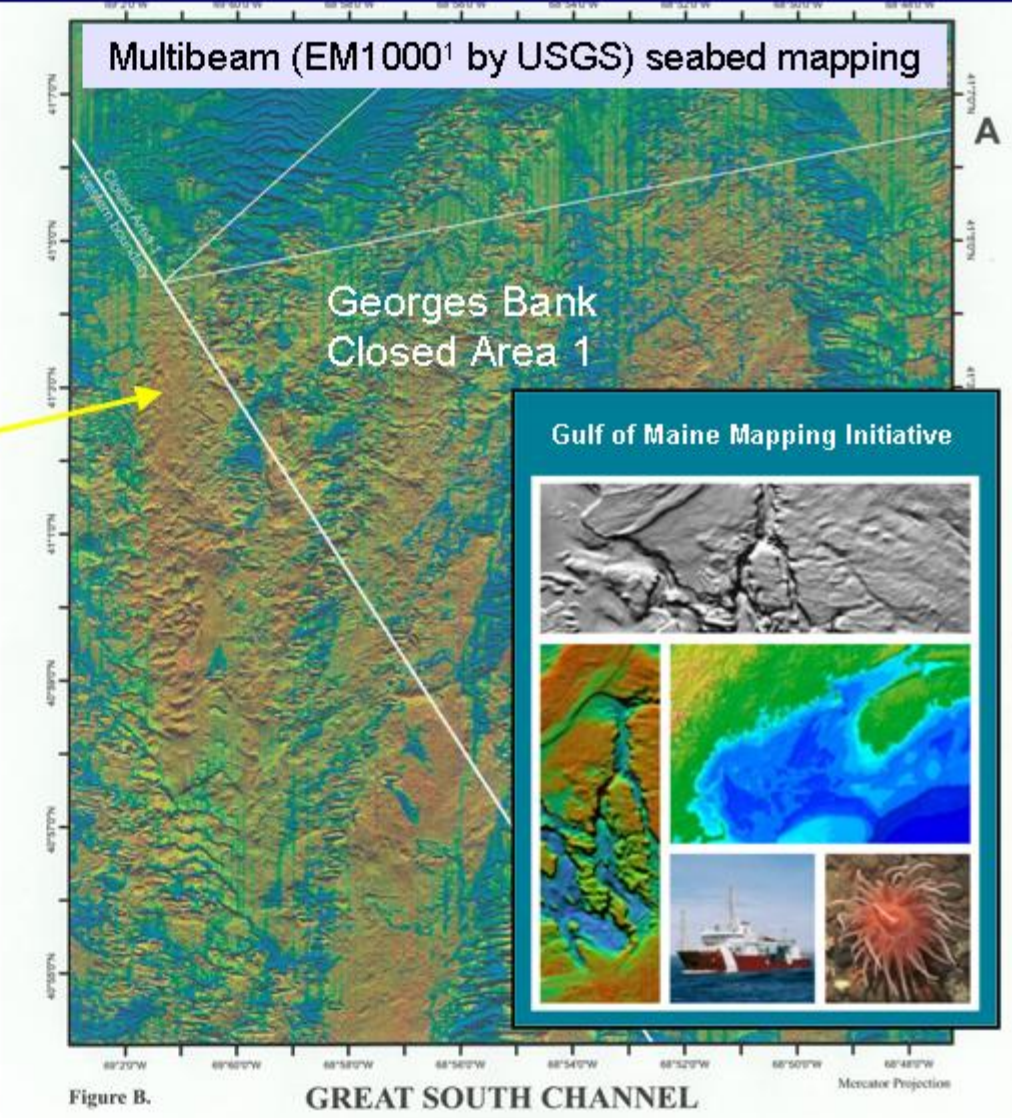
for improving habitat conservation & fisheries management



Multibeam on Browns Bank by the CHS has reduced gear effects on habitat & increased CPUE for fishing industry.



Ginette Robert, Bedford Institute of Oceanography and Canadian Offshore Scallop Industry Mapping Group



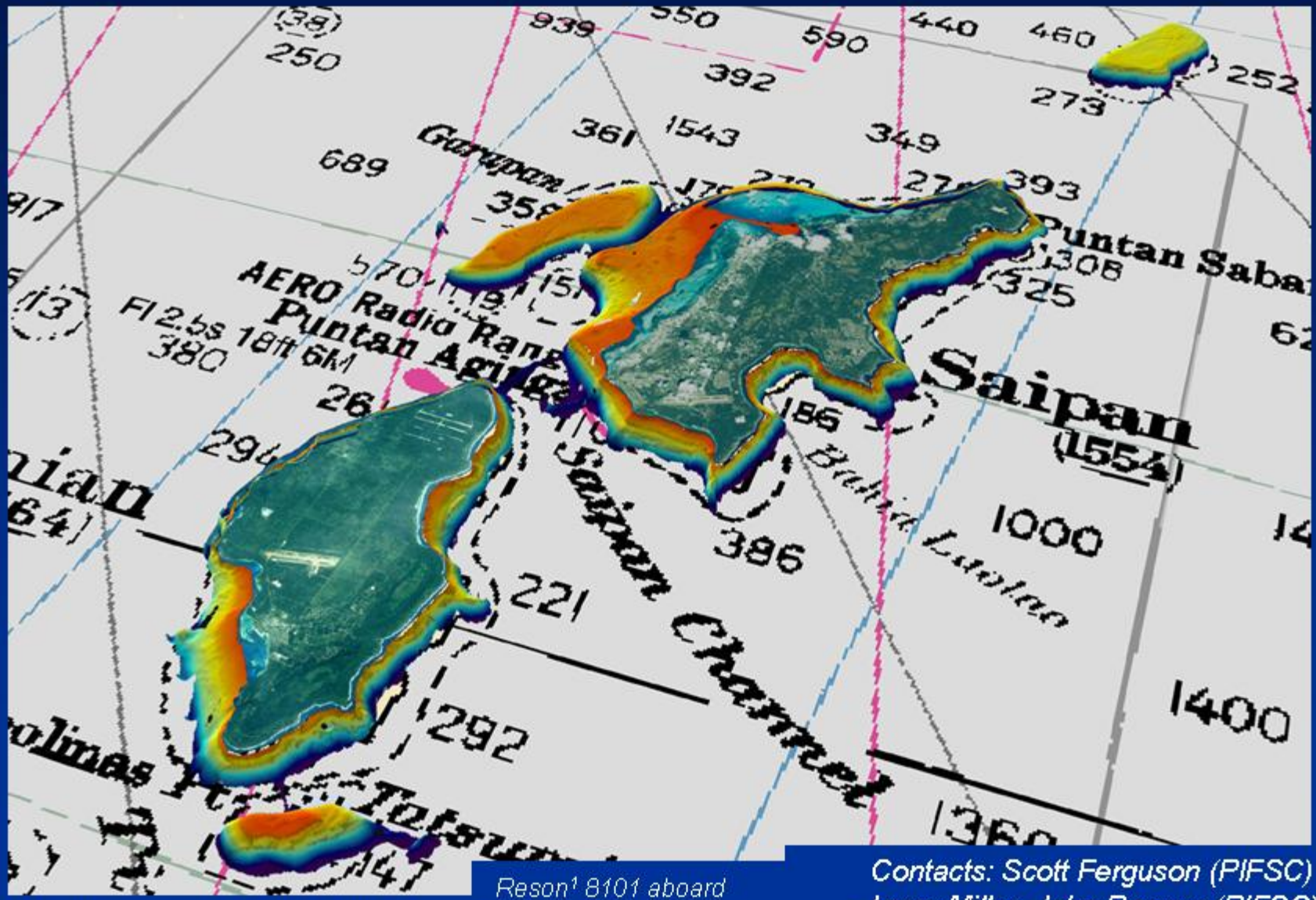
Contacts: Page Valentine (USGS)
Tom Noji (NEFSC) Leslie-Ann McGee (NEFMC)

[1] Does not imply endorsement of vendor's product

Example of Multibeam Habitat Mapping in the PIFSC Region

to improve habitat conservation and protection (Coral Reef Protection & MPAs)

Multibeam (Reson[1] 8101) bathymetry (20-250 m) & satellite (IKONOS) imagery



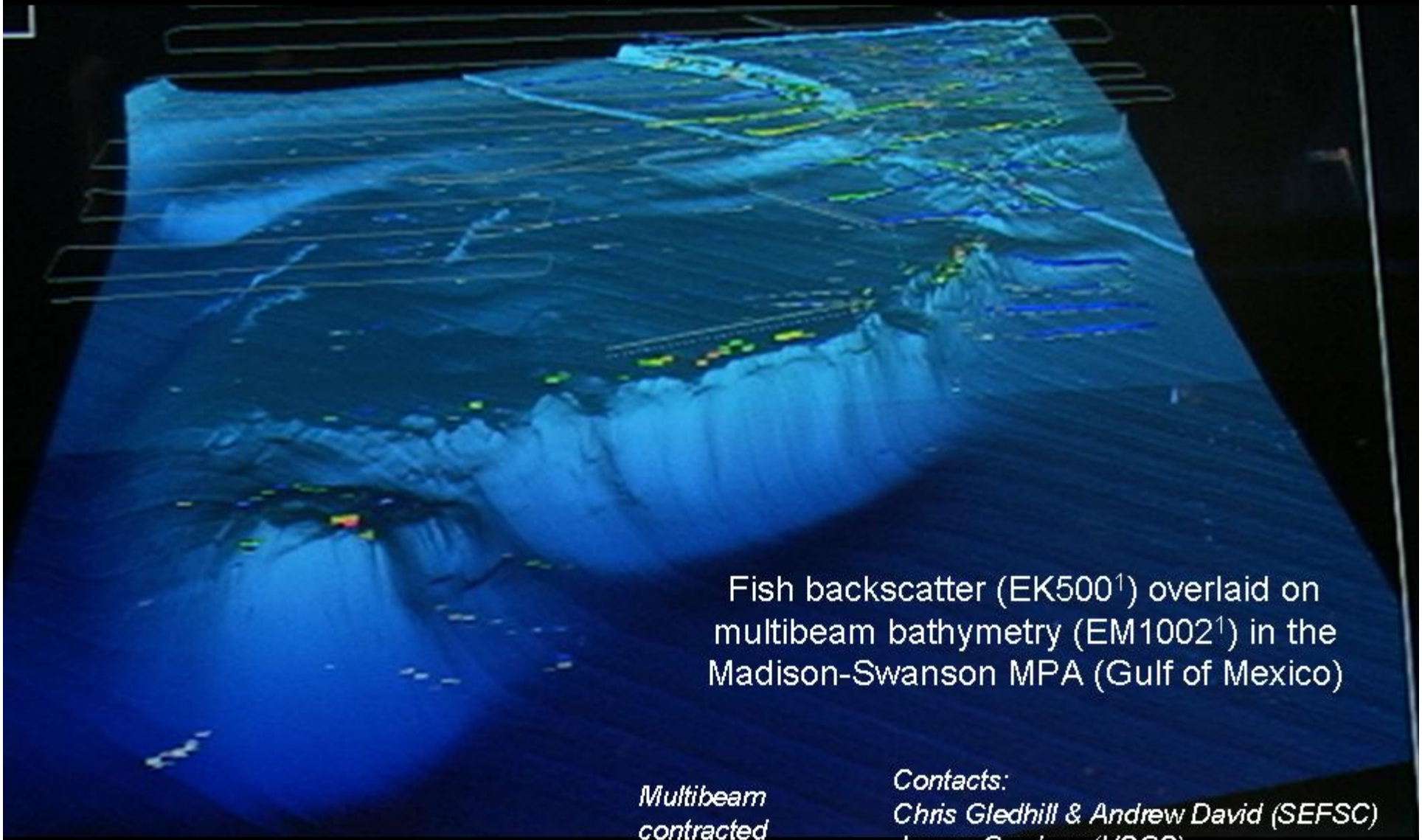
[1] Does not imply endorsement of vendor's product

Reson[1] 8101 aboard NOAA RV Adventurer

Contacts: Scott Ferguson (PIFSC)
Joyce Miller, John Rooney (PIFSC)

Example of Multibeam Research in the SEFSC Region

Synoptic watercolumn & seafloor multibeam backscatter is required for fisheries management & habitat conservation



Fish backscatter (EK500[1]) overlaid on multibeam bathymetry (EM1002[1]) in the Madison-Swanson MPA (Gulf of Mexico)

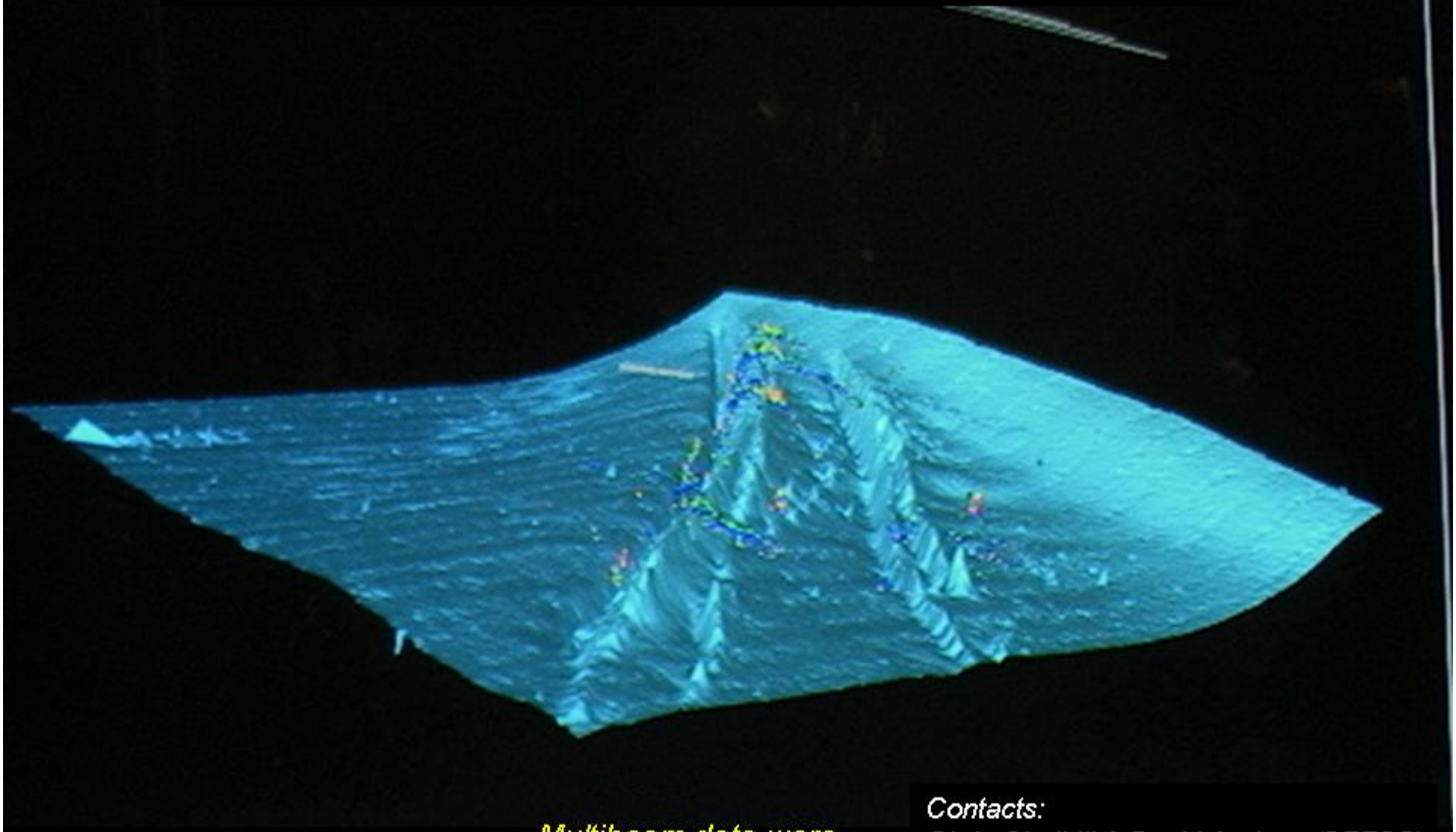
Multibeam contracted from USGS

Contacts:
Chris Gledhill & Andrew David (SEFSC)
James Gardner (USGS)
David Naar (Univ. S F

[1] Does not imply endorsement of vendor's product

Examples of Multibeam Research in the SEFSC Region

- Fish backscatter (EK500[1]) overlaid on multibeam bathymetry (EM3000[1]) in the Twin-Ridges MPA (Gulf of Mexico)



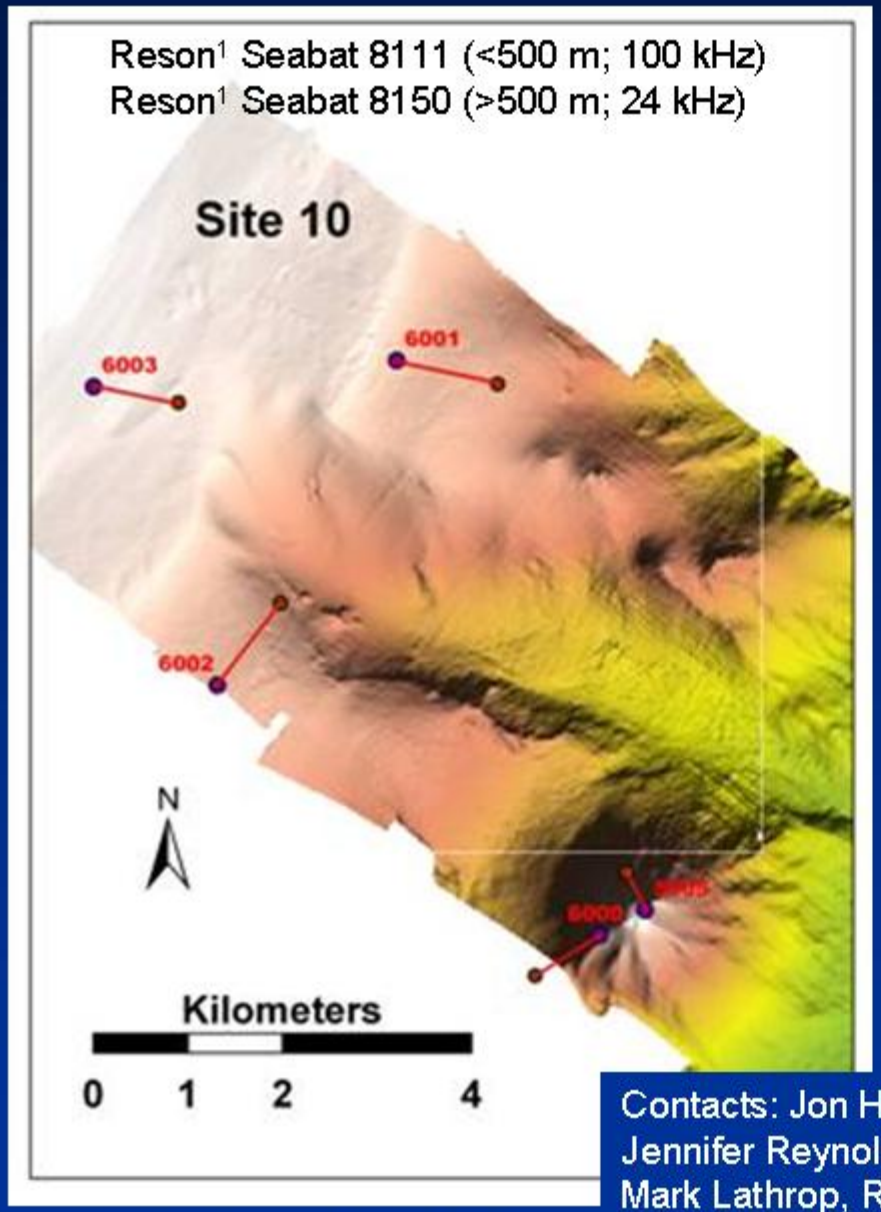
Multibeam data were contracted from USF

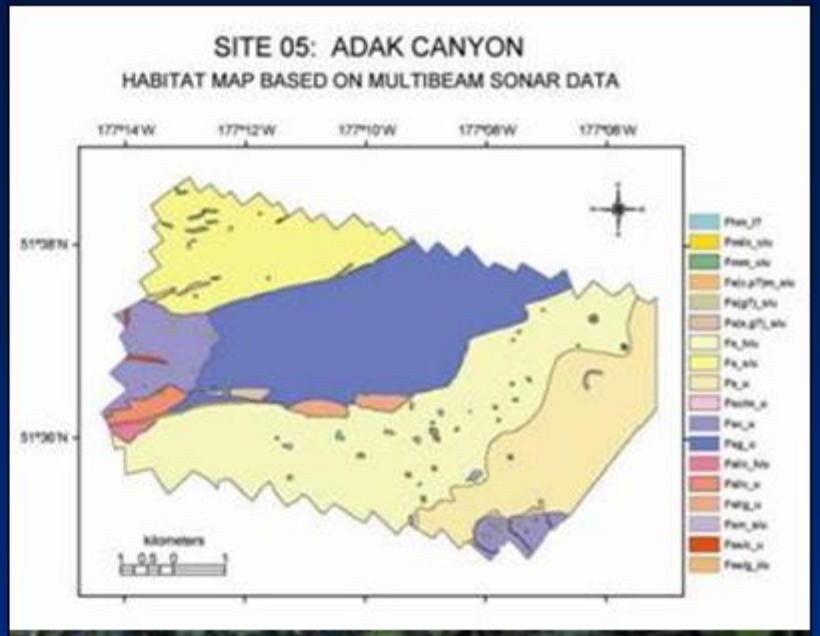
Contacts:
Chris Gledhill & David Andrew (SEFSC)
David Naar (USF)

[1] *Does not imply endorsement of vender's product*

Collaborative Multibeam Research in the AFSC Region

Habitat classification & mapping in the Gulf of Alaska & Aleutian Islands



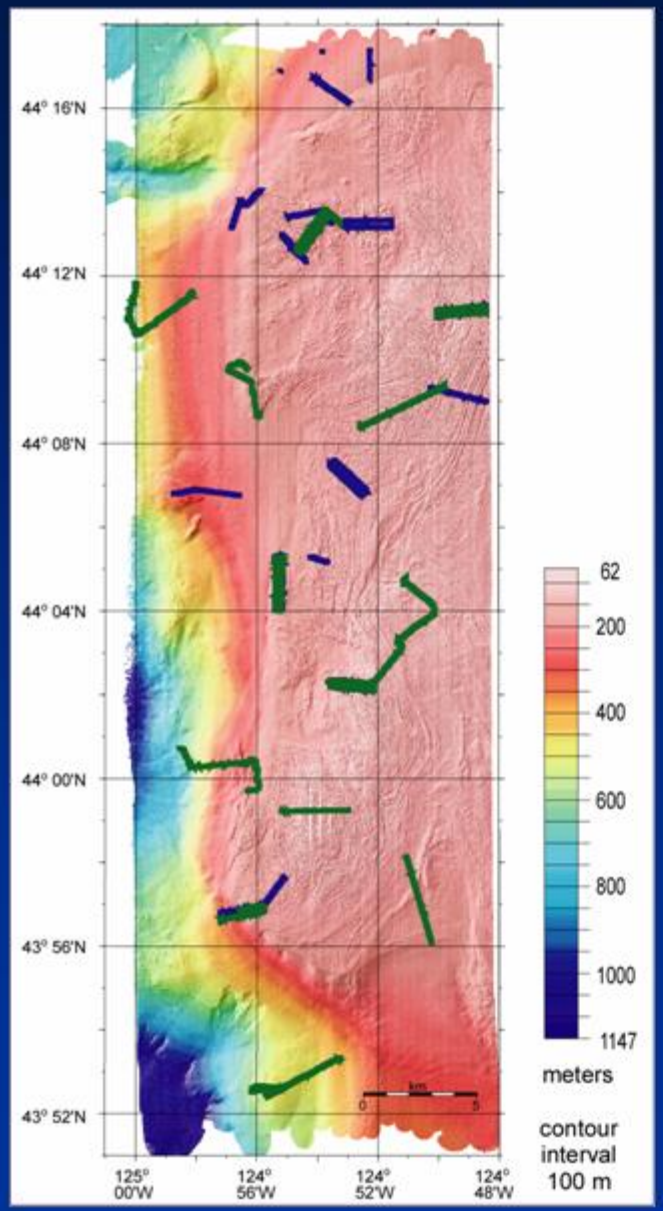


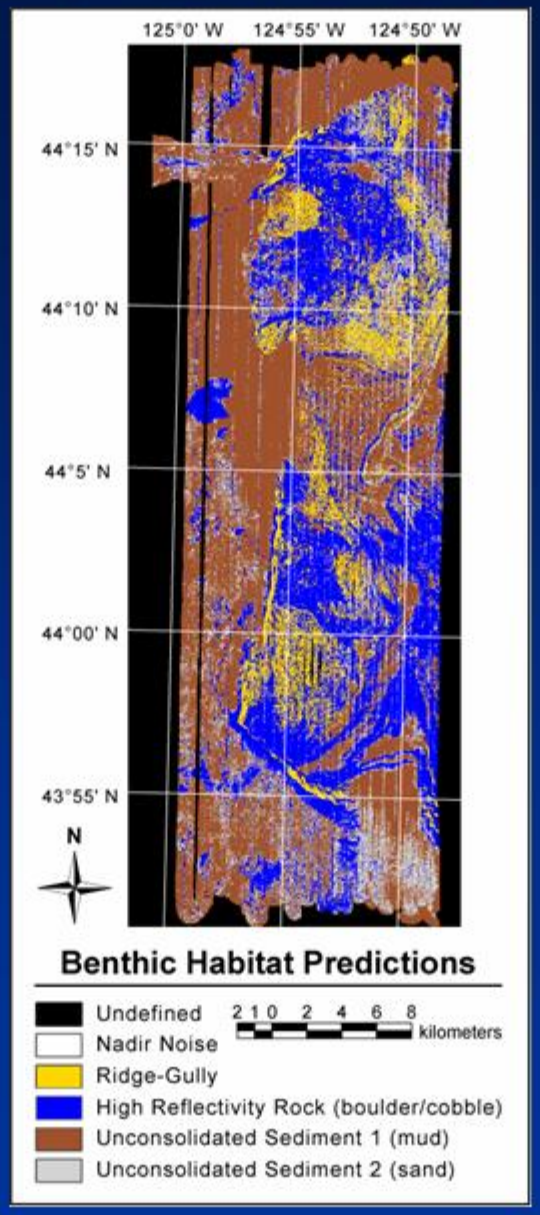
Contacts: Jon Heifetz (AFSC)
Jennifer Reynolds (UAF)
Mark Lathrop, Rick Fletcher (NOS)
Doug Woodby (ADF&G)

[1] *Does not imply endorsement of vendor's product*

Example of Habitat Mapping in the NWFSC Region

for improving fisheries management & habitat conservation.





High resolution bathymetry & habitat classification from EM300[1] (30 kHz) multibeam & ROPOS ROV observations

Demersal fish habitats classified and mapped using quantitative indices derived from multibeam bathymetry & seafloor backscatter data.

Ongoing research to develop methods for extrapolating fish densities observed from submersibles to multibeam survey area.

Contacts:
Waldo Wakefield (NWFSC)
Curt Whitmire (NWFSC)
Mary Yoklavich (SWFSC)
Bob Embley (NOAA/OAR/PMEL)

[1] *Does not imply endorsement of vendor's product*

Fisheries Multibeam Research in the AFSC Region

NOAA FSV Oscar Dyson recently installed with
NOAA's first hull-mounted multibeam system (SM2000 [1] 90kHz)
designed for bathymetric & watercolumn backscatter research.
A similar (or equivalent) hull-mounted multibeam system is proposed
for the second NOAA FSV-40 to be delivered to the NEFSC

[1] *Does not imply endorsement of vendor's product*

Example of Multibeam Research in NWFSC & SWFSC Regions

for improving fisheries management & habitat conservation

A poled-mounted SM2000[1] (90 kHz) provided high resolution bathymetry (approximately 10 m resolution) of 200-400m depths on the Pilgram Bank.

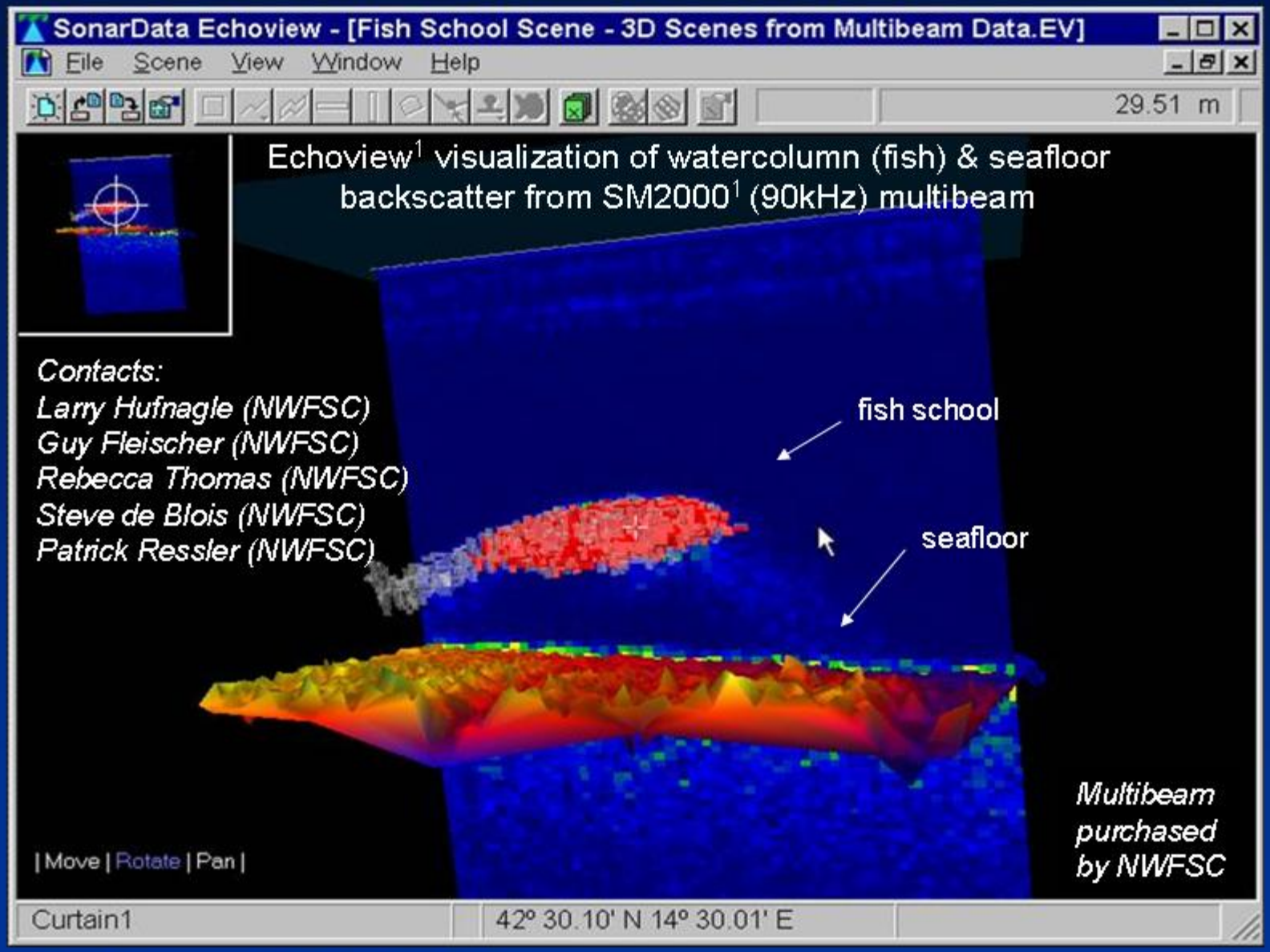
Multibeam purchased by NWFSC

Contacts:
Larry Hufnagle & Waldo Wakefield (NWFSC)
Mary Yoklavich & Mark Amend (SWFSC)
Chris Goldfinger (OSU)

[1] *Does not imply endorsement of vendor's product*

Example of Multibeam Research in the NWFSC Region

Watercolumn & bathymetric multibeam (SM2000[1]) backscatter is required for improving fisheries management & habitat conservation

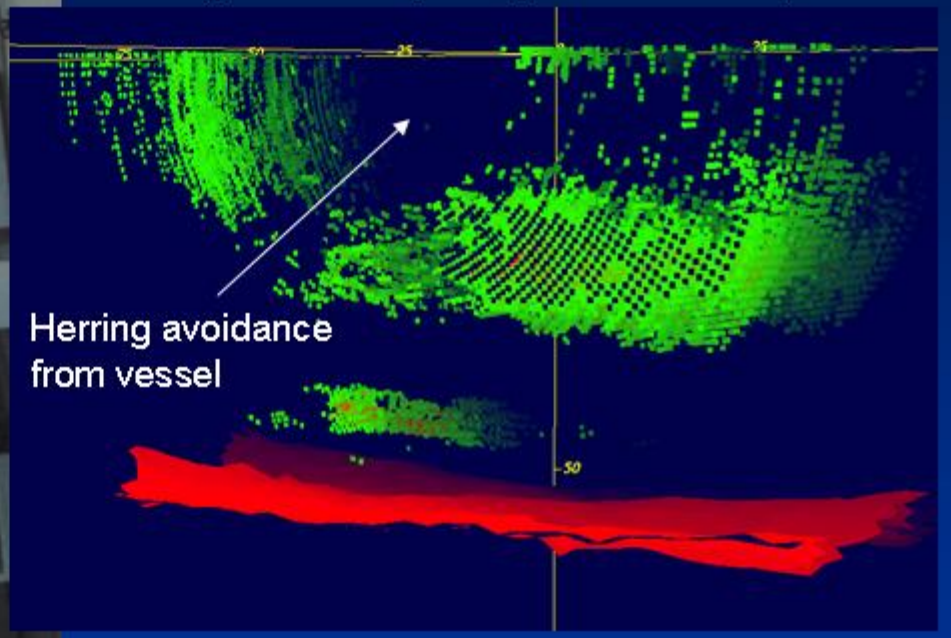


[1] *Does not imply endorsement of vendor's product*

Example of Collaborative Research in NEFSC & NW Atlantic Region

Multibeam field experiments for improving fish population estimates

SM2000[1] 3-D backscatter of herring schools on German Bank (provided by Gary Melvin, DFO)



Intervessel comparisons (SM2000[1] & EK500[1]) during cooperative NEFSC & DFO herring acoustic surveys on Georges Bank

Multibeam system is owned by DFO & Can. Pelagic Fish Comm.

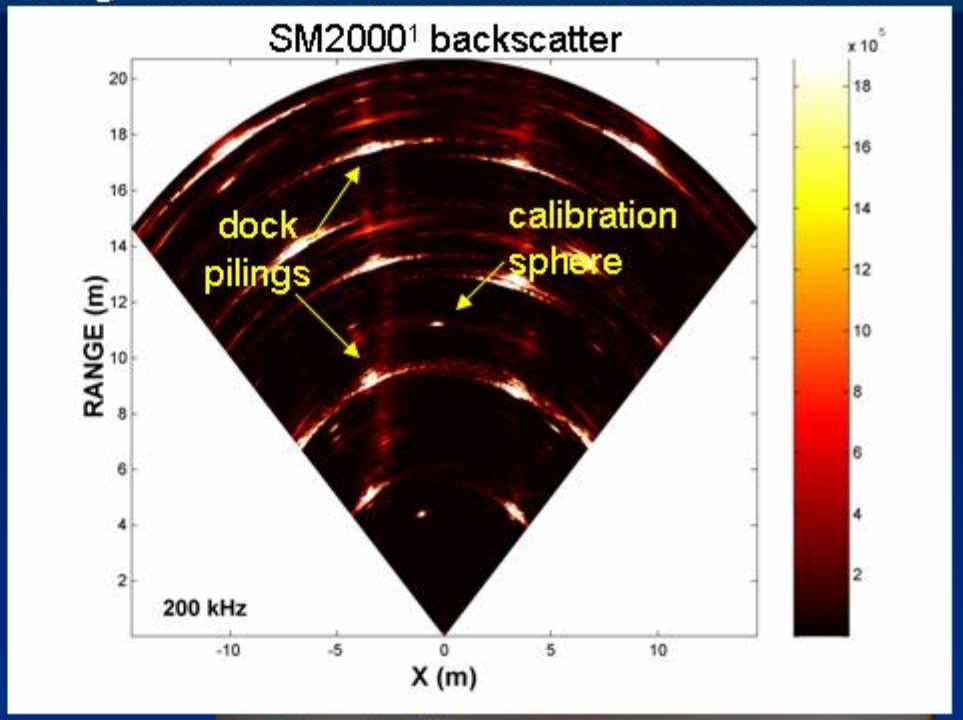
Contacts:
Gary Melvin (DFO)
Larry Mayer (UNH)
Mike Jech (NEFSC)
Bill Michaels (NEFSC)

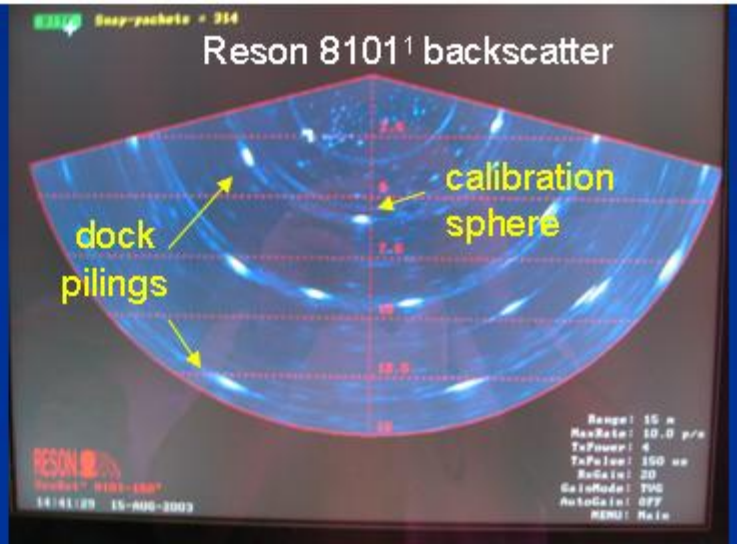
[1] Does not imply endorsement of vendor's product

Example of Collaborative NOAA & Extramural Multibeam Research

to establish calibration procedures & quantitative backscatter calculations for improving fisheries assessments using watercolumn multibeam backscatter

Multibeam transducer is rotated at 0.1 degree increments



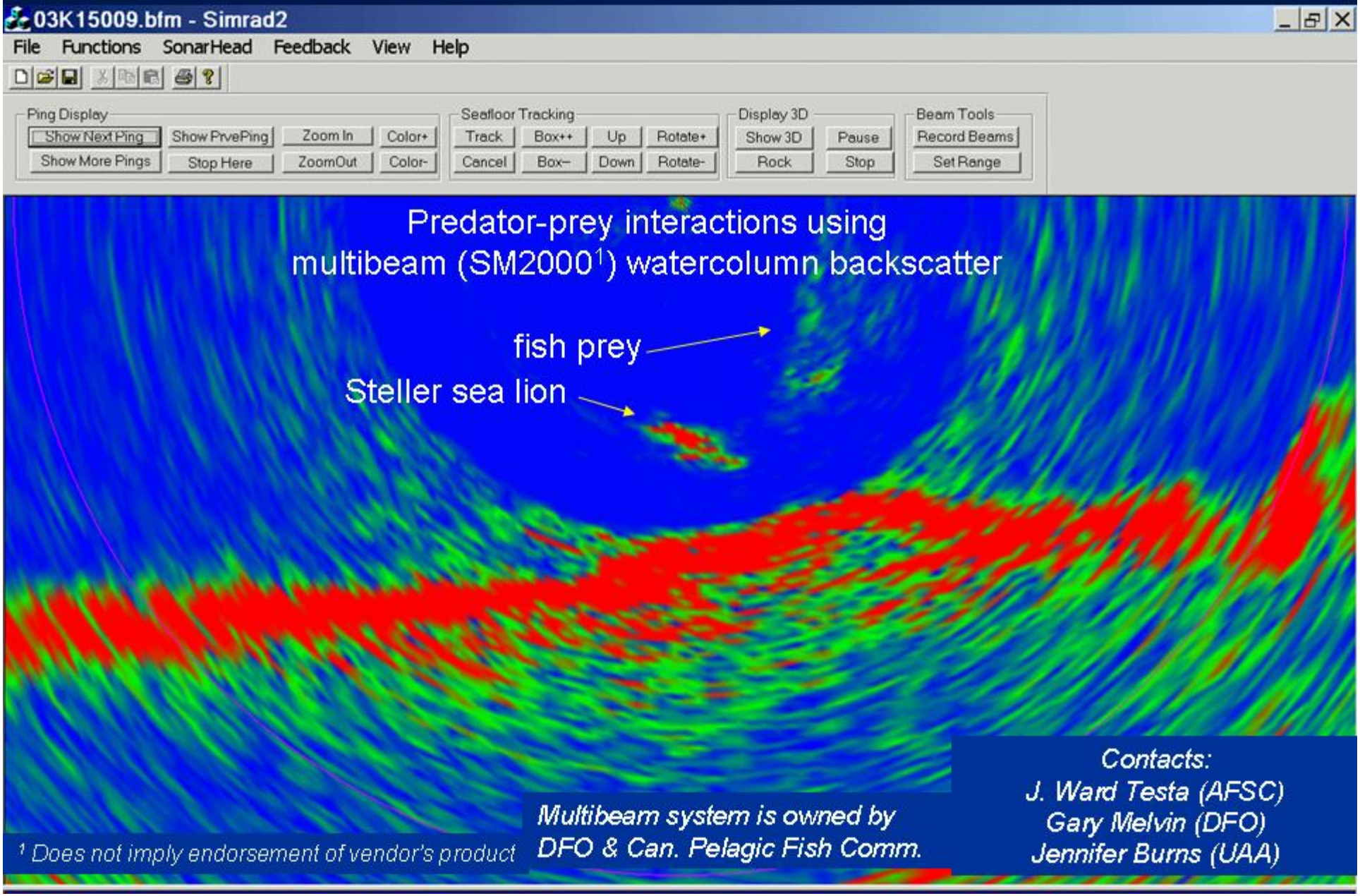


Contacts:
Ken Foote & Dezhang Chu (WHOI)
Larry Mayer & Ken Baldwin (UNH)
Mike Jech & Bill Michaels (NEFSC)
Larry Hufnagle (NWFSC)

[1] Does not imply endorsement of vendor's product

Example of Multibeam Research in the AKFSC Region

Multibeam watercolumn backscatter for Protected Marine Species research



[1] *Does not imply endorsement of vendor's product*

Multibeam system is owned by DFO & Can. Pelagic Fish Comm.

Contacts:
J. Ward Testa (AFSC)
Gary Melvin (DFO)
Jennifer Burns (UAA)

Examples of Next Generation Multibeam Systems

Vendors are developing advanced multibeam systems (e.g., Simrad MBES[1])
to improve watercolumn & seafloor (IHO) backscatter capabilities

Figure 1 Multibeam Echo Sounder (MBES)

MBES[1] multibeam
Freq. 70-120 kHz
Operating range >450m
Instant. DR 150 dB
47 beam transducer
17 split-beams
Split-beams 2^0-7^0x2^0-7^0
Two steered split-beams
for comparison studies
with echosounders

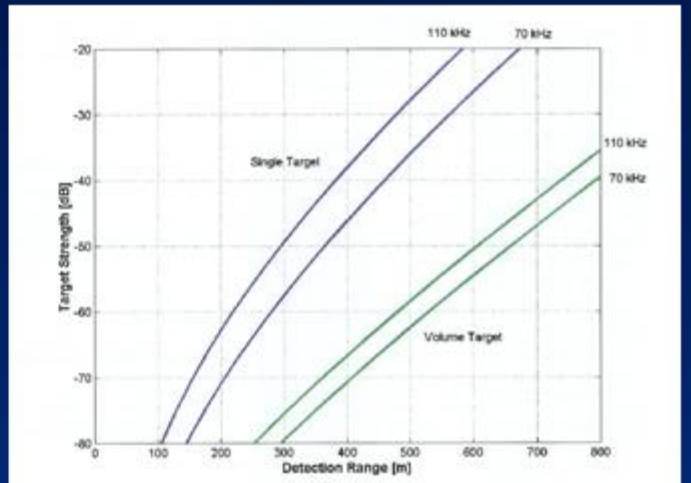


Figure 14 Calculated detection range for MBES

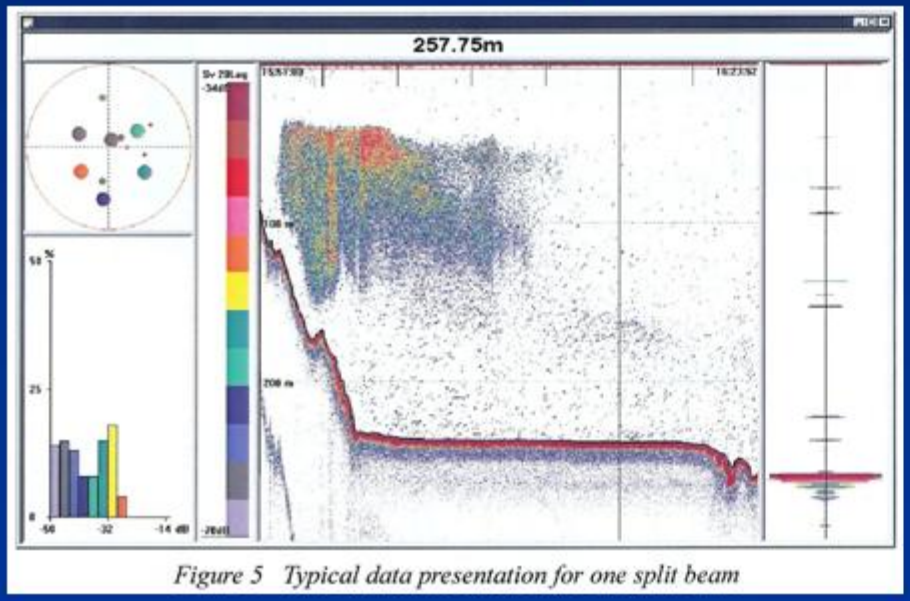
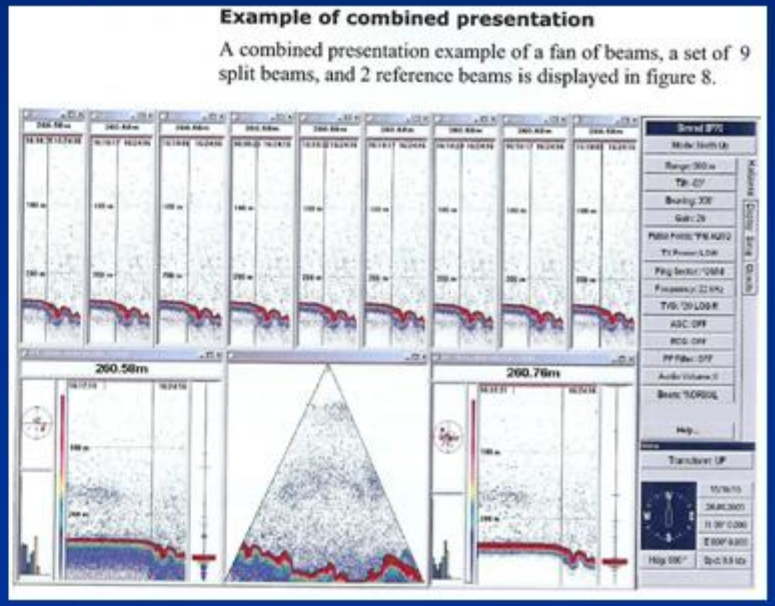


Figure 5 Typical data presentation for one split beam

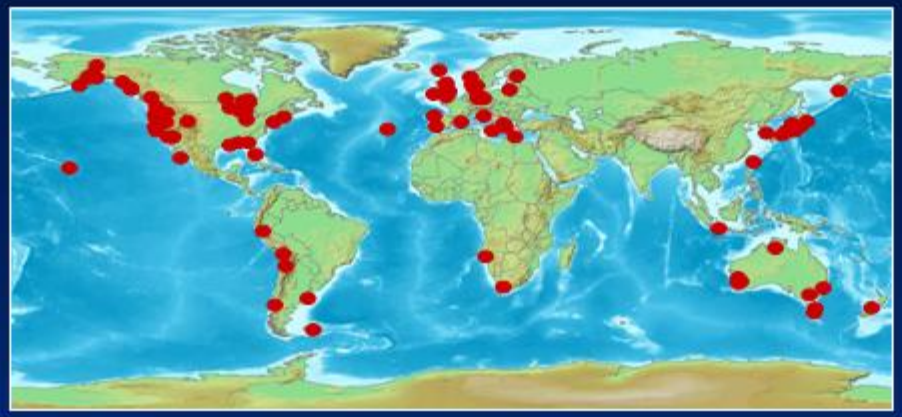


[1] Does not imply endorsement of vendor's product

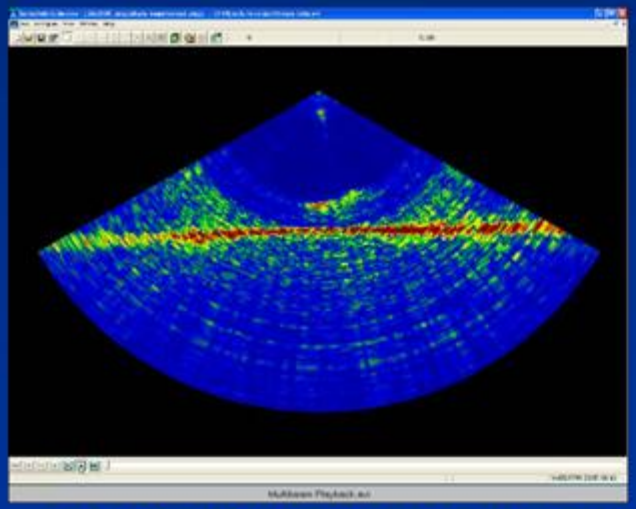
Other next generation multibeam systems will soon be available

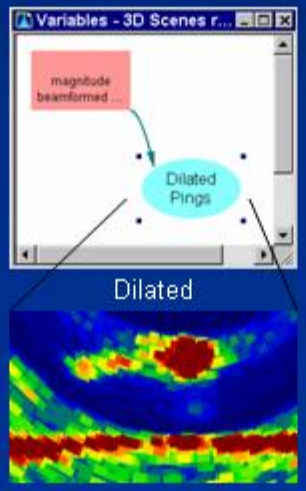
Examples of Next Generation Multibeam Systems

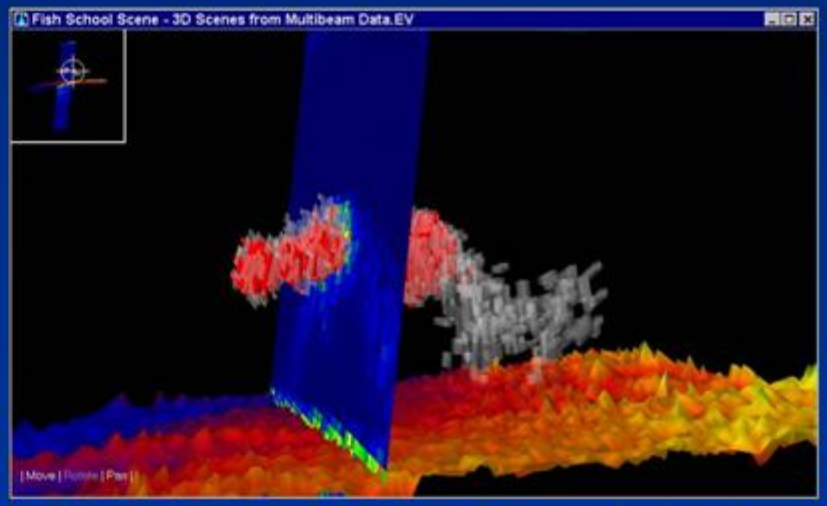
Vendors (e.g., SonarData[1]) have developed (& continue to upgrade) software providing visualization and analytical tools for various acoustic systems



SonarData[1] software recently supports SM2000[1] and Reson 6012[1] multibeams, & their next upgrade supports EM3002[1], Reson 8101[1] & 8125[1], Didson[1] multibeams





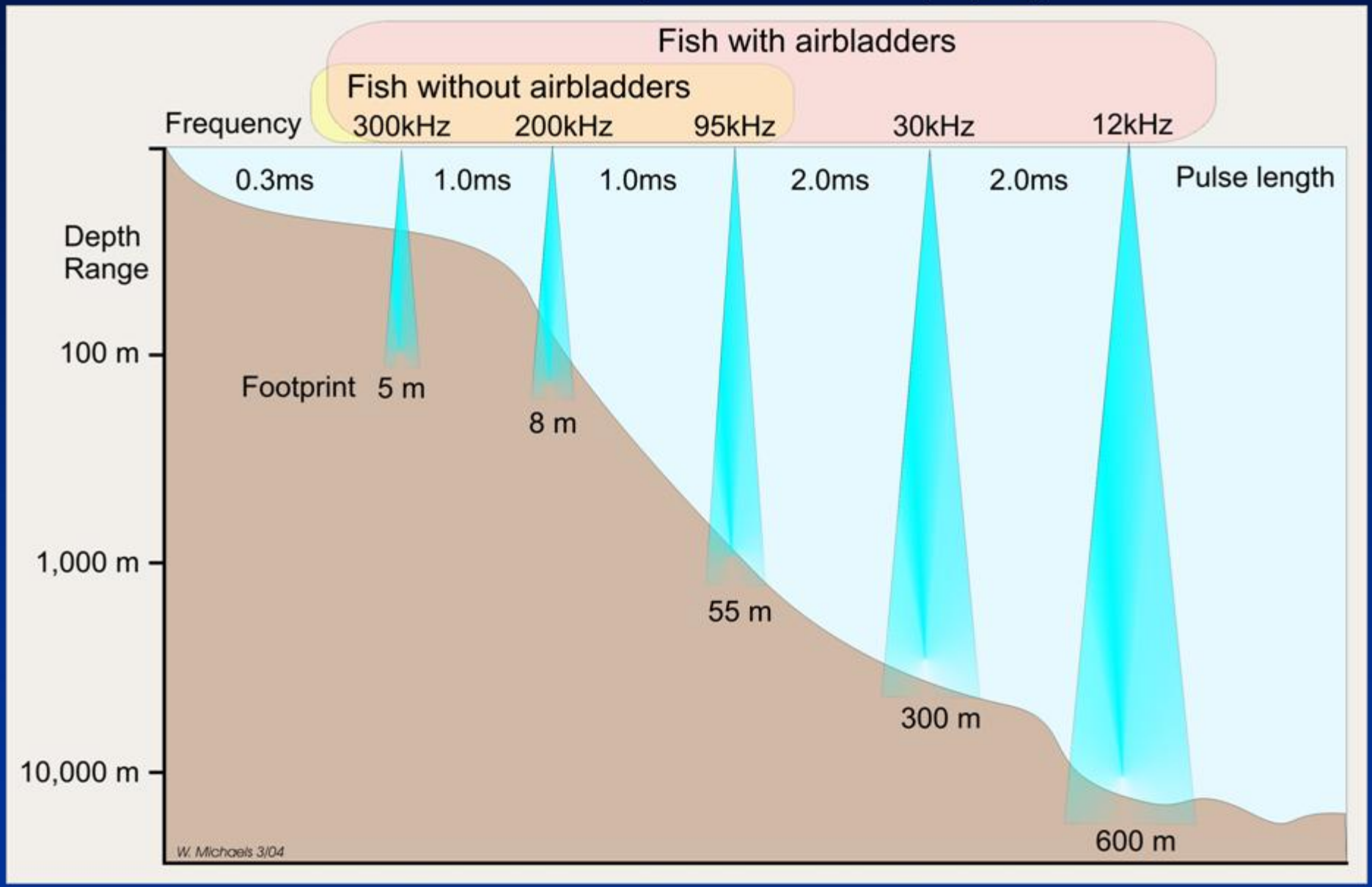


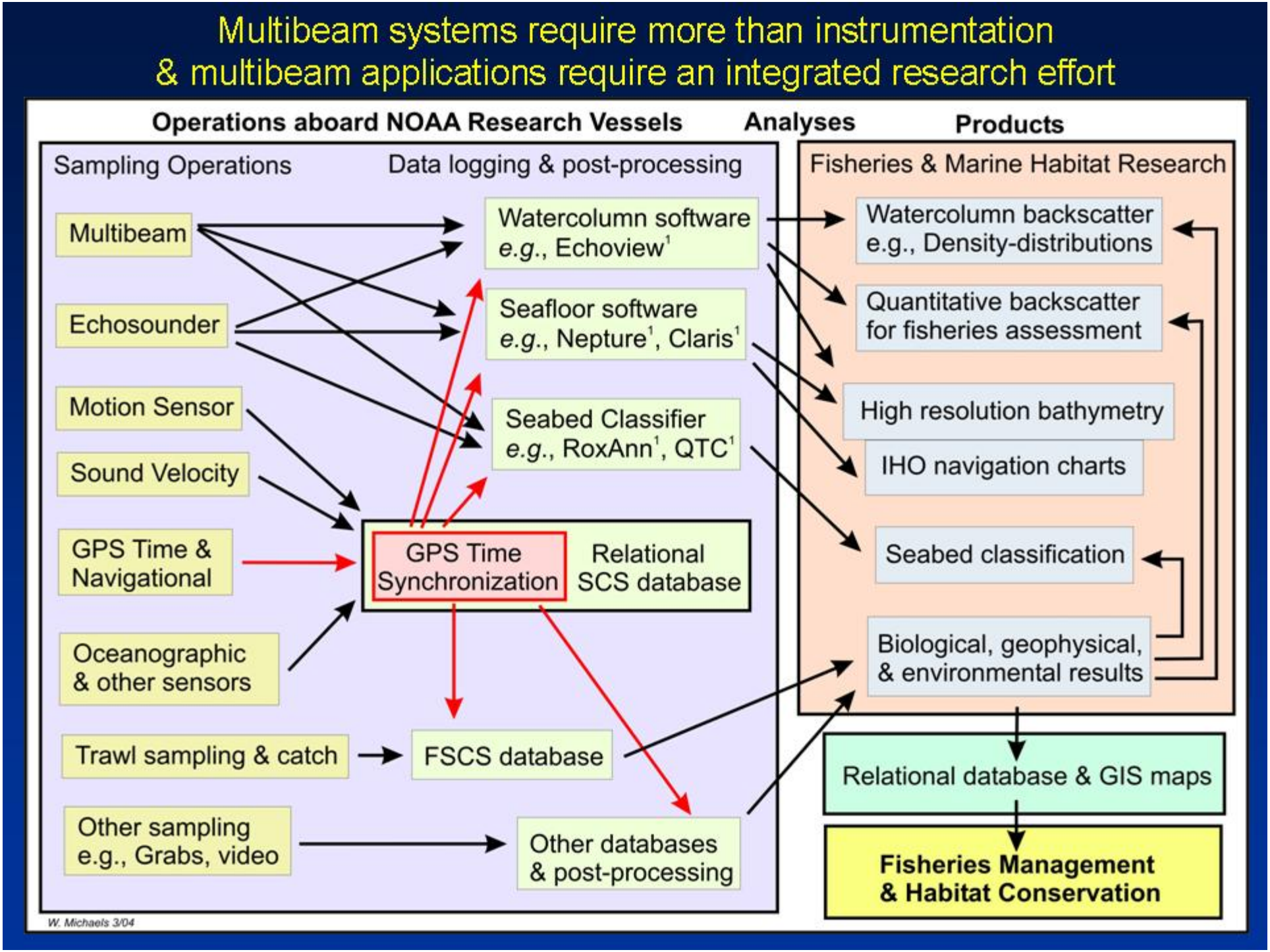
**** Scientists & vendors working closely to develop high-quality products ****

[1] *Does not imply endorsement of vendor's product*

There are other examples of multibeam software developments

Multibeam system requirements are dependent on survey depth range & detection (e.g., fish & seabed) resolution, therefore multibeam requirements will vary by region




Multibeam systems require more than instrumentation
& multibeam applications require an integrated research effort
Operations aboard NOAA Research Vessels
Analyses
Products
Sampling Operations
Data logging & post-processing
Fisheries & Marine Habitat Research
Multibeam
Echosounder
Motion Sensor
Sound Velocity
GPS Time & Navigational
Oceanographic & other sensors
Trawl sampling & catch
Other sampling e.g., Grabs, video
Watercolumn software e.g., Echoview[1]
Seafloor software e.g., Nepture[1], Claris[1]
Seabed Classifier e.g., RoxAnn[1], QTC[1]
GPS Time Synchronization
Relational SCS database
FSCS database
Other databases & post-processing
Watercolumn backscatter e.g., Density-distributions
Quantitative backscatter for fisheries assessment
High resolution bathymetry
IHO navigation charts
Seabed classification
Biological, geophysical, & environmental results
Relational database & GIS maps
Fisheries Management & Habitat Conservation
W. Michaels 3/04

Conclusions on Multibeam Requirements for Fisheries Management

Synoptic watercolumn & seafloor multibeam operations provide cost-effective, accurate, and timely products for NOAA's Strategic Plan.

Multibeam watercolumn & seafloor products are required for fisheries management

Multibeam watercolumn & seafloor applications for improving fisheries research & marine habitat conservation has been demonstrated in each region.

Multibeam systems can presently be used operationally aboard NOAA vessels for most fisheries research, however further R&D is required for quantitative population estimates.

Multibeam requirements vary w/ survey depth range & detection (*e.g.*, fish & seabed).

Next generation multibeam systems will provide improved dual purpose (watercolumn and IHO seafloor) capabilities.

Scientists & vendors working closely together provide high-quality & integrated multibeam systems with analytical tools.

Pre-purchase Considerations for Multibeam aboard NOAA vessels

Provide integrated ("cross-cutting") research for cost-effective, accurate, & timely products in support of NOAA's Strategic Plan

High quality products to accomplish (& defend) mandated responsibilities

Priorities should also consider NOAA vessel sea-day allocation, cruise objectives, & vessel's operational capabilities for groundtruthing.

Multibeam systems include more than simply instrumentation

Calibration requirements (e.g., system, reference & training sets) including before and after installation

Vendor support, including close working relationship with scientists with research & development