

Science, Service, Stewardship



Atlantic Marine Assessment Program for Protected Species (AMAPPS)

Distance Sampling

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Outline

1. Where does this talk fit in
2. Overview of the AMAPPS project
3. More details on abundance surveys and methods
4. Strengths/Challenges/Recommendations

Data collection and monitoring programs

Abundance/Distribution



AMAPPS



Human interactions (Bycatch
Ship strikes, Noise, Other)

Stock structure
Life history
Ecology

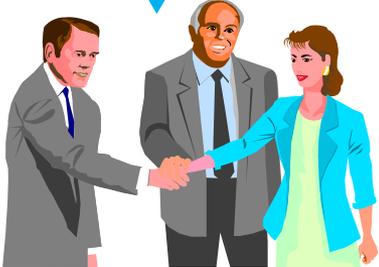


Assessment Reports

ESA Recovery Plans
Status Review
Section 7 consultations



Assess Potential Impacts of
Human Activities and
Climate Changes



MMTA Take Reduction
Teams

Monitoring and
Evaluating Plans

GAR's needs discussed in this presentation

- **Abundance and distribution**
 - Population abundances and trends
 - Availability of species to surveys for abundance
 - Investigate seasonal distribution and behavior
 - Focus on particularly sensitive species
 - Coordinate with Canada on transboundary stocks and threats
 - Project future distribution under changing environment
- **Improve understanding of stock structure**
- **Assessments**
 - Predict future distributions and risk profiles of species based on ecology, behavior, habitat relationships, and predicted threats
 - Include demography in population density/distribution work
 - Ecology, behavior, & distribution of species related to current threats
 - Population viability analysis
 - Provide science to inform ecosystem models



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Overview of abundance estimates

- Which species do we deal with?
- How often do we conduct surveys and provide estimates?

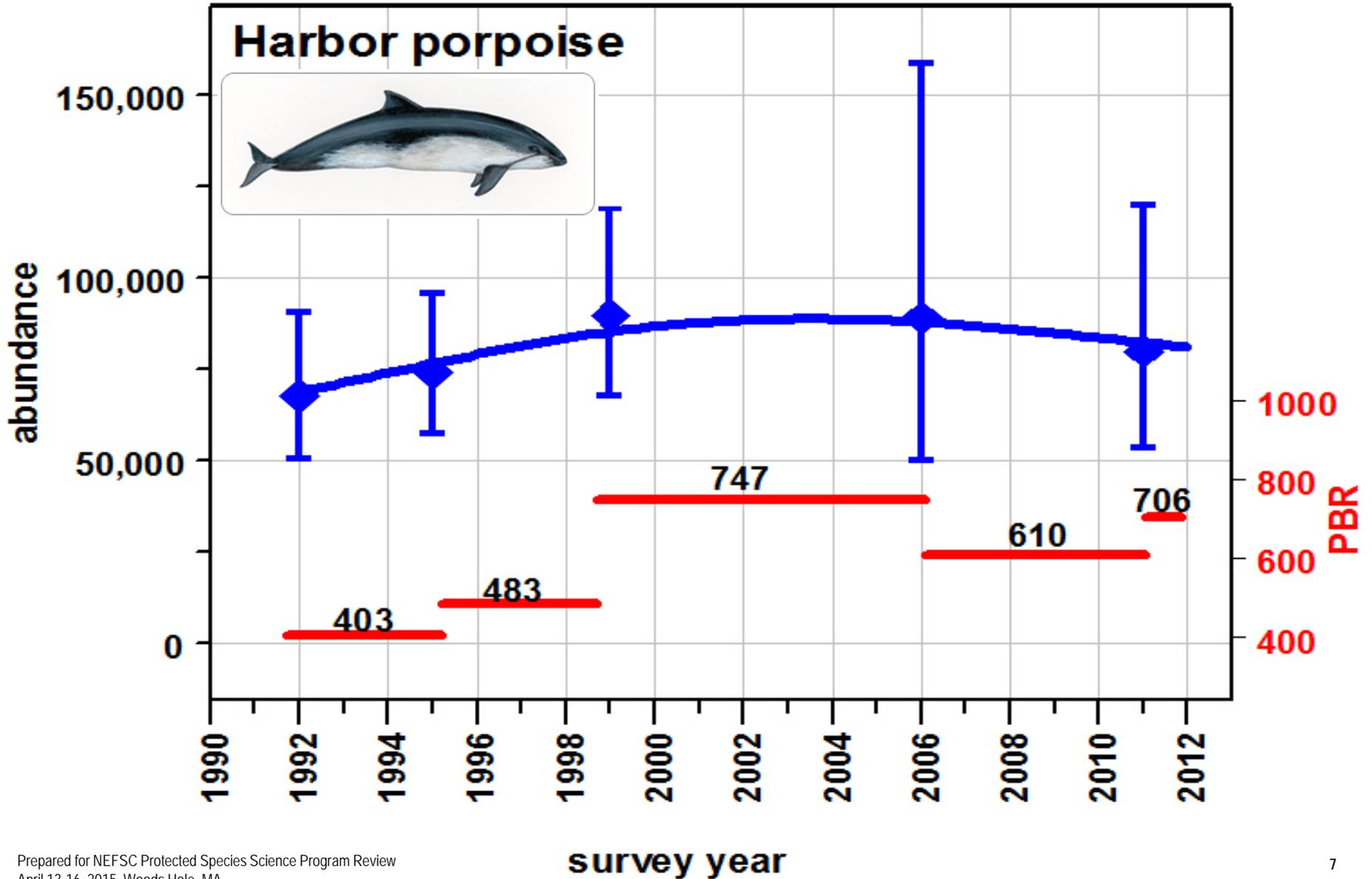
Species line-transect surveys used to estimate abundance (see Appendix IV of SAR for details)

- Humpback whale*
- Fin whale
- Sei whale
- Minke whale
- Sperm whale
- Dwarf sperm whale
- Pygmy sperm whale
- Cuvier's beaked whale
- Other beaked whales
- Risso's dolphin
- Pilot whale, spp
- Atlantic white-sided dolphin
- White-beaked dolphin⁺
- Common dolphin
- Atlantic spotted dolphin
- Striped dolphin
- Rough-toothed dolphin⁺
- Harbor porpoise

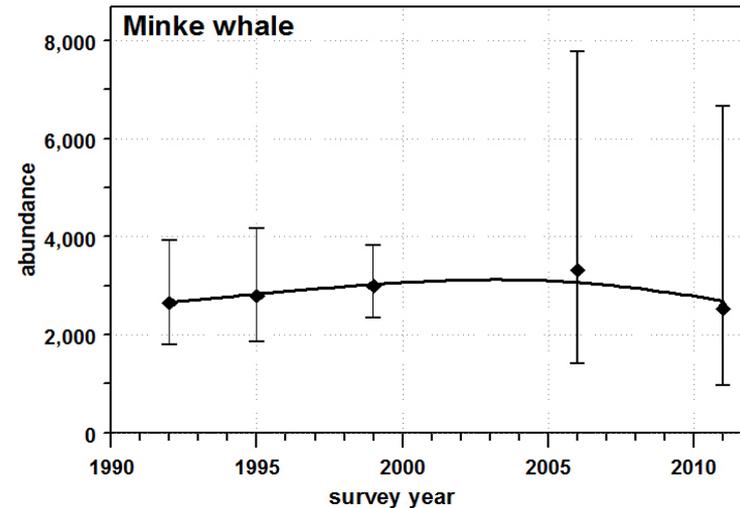
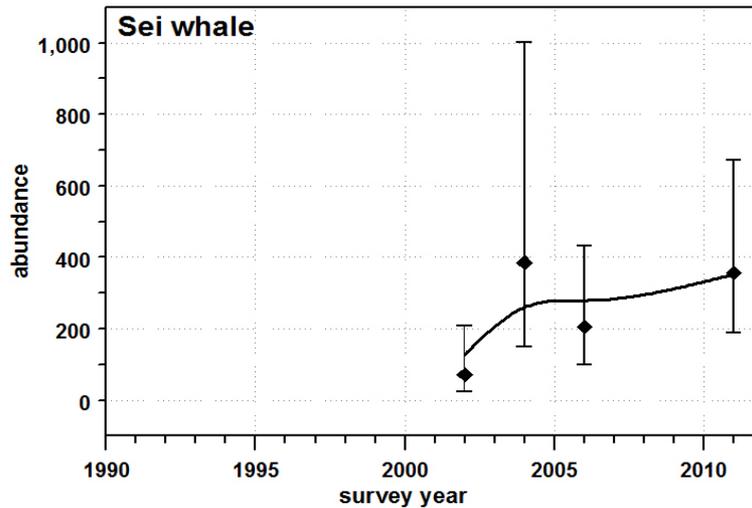
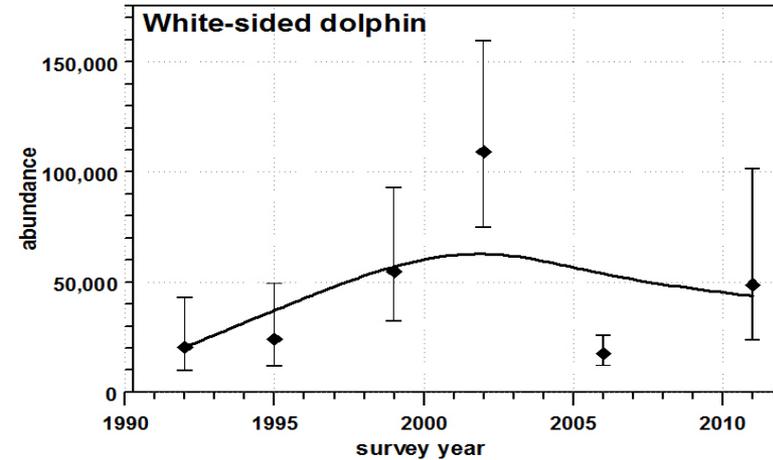
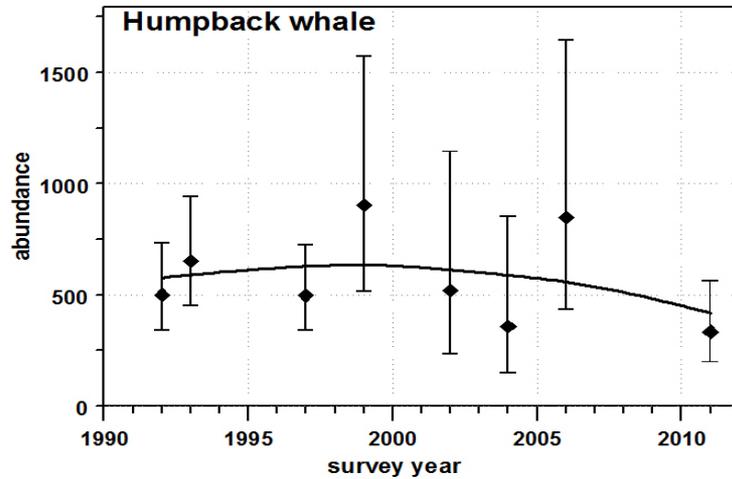
* Sometimes have used a photographic or genetics capture-recapture estimated instead of line transect

+ When data are available (not seen in every survey)

Abundance estimate series using summer data



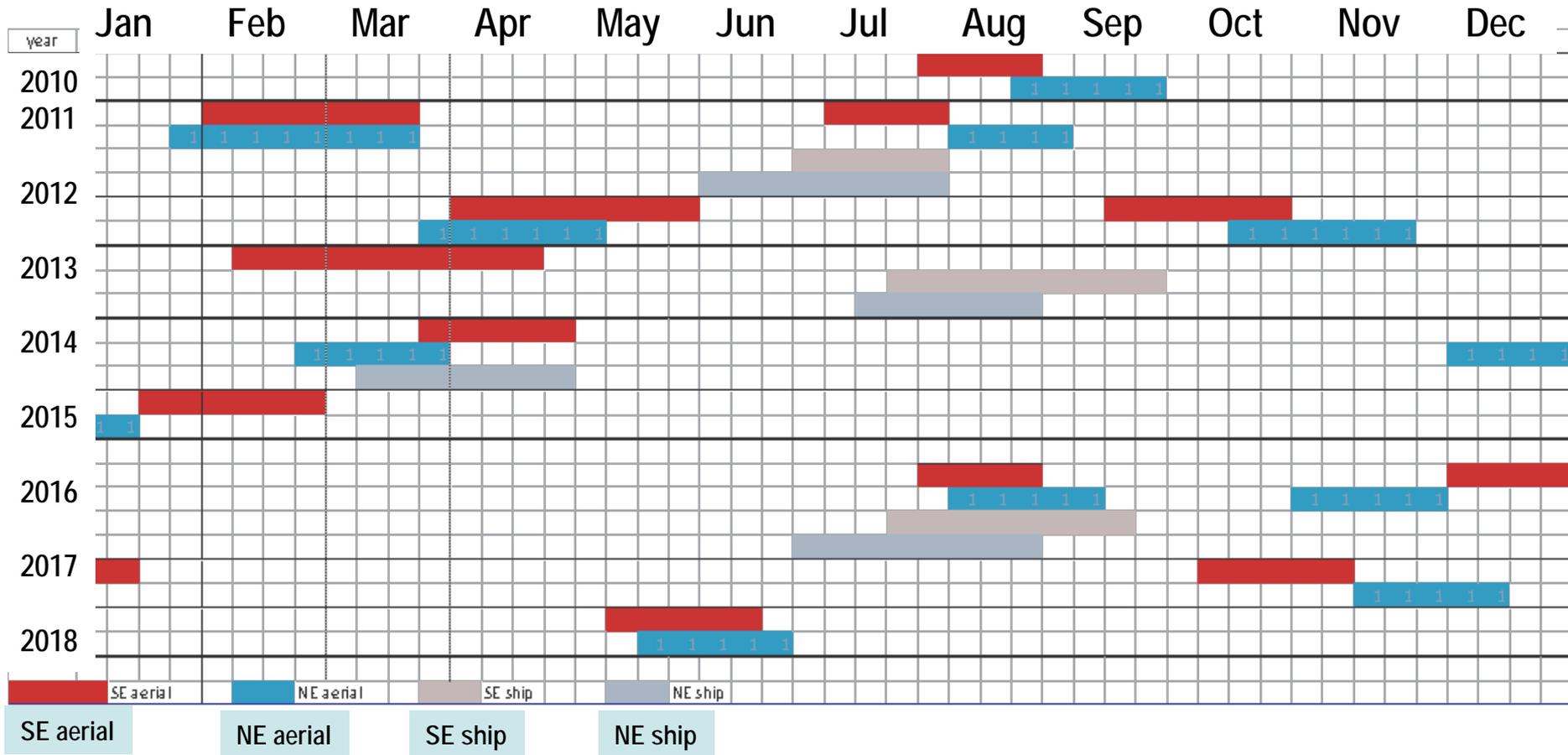
Summer time series for a few other species



Timing of ship and aerial surveys since 2010

Planning another NE + SE ship + plane survey summer 2016

Coordinating with Canada and parts of EU to have a larger survey effort over the North Atlantic



Background of AMAPPS

- Work conducted by NEFSC/SEFSC and USFWS
- Inter-agency agreements with BOEM and Navy
- Collaborative efforts with many other organizations
- AMAPPS I: 2010 – 2014
 - Data collection during 2010 – 2014
 - Expecting density models/maps to be completed in summer 2015
- AMAPPS II: 2015 – 2019
 - Had coordinating meeting in Aug 2014 with 13 agencies to discuss future data needs



Objectives – Collect new data

- **Collect broad-scale data over multiple years on the seasonal distribution and abundance** of marine mammals (cetaceans and pinnipeds), marine turtles, and sea birds using direct aerial and shipboard surveys of coastal U.S. Atlantic Ocean waters
- **Collect similar data at finer scales** at several (~3) sites of particular interest to NOAA partners using visual and acoustic survey techniques
- **Conduct tag telemetry studies** within surveyed regions of marine turtles, cetaceans, pinnipeds and sea birds to develop corrections for availability bias in the abundance survey data and to collect additional data on habitat use, life-history, residence time, acoustic behavior and frequency of use.

Objectives - Analyses

- **Assess the population size and/or density estimates of surveyed species at regional scales**
- **Explore alternative platforms and technologies to improve population assessment studies**
- **Develop models and associated tools to translate these survey data into seasonal, spatially-explicit density estimates incorporating habitat characteristics**

Monitoring density/abundance and distributions

1. Via transect surveys

- Seabirds - 9 coastwide aerial surveys ~ 89,500 km of survey effort
- Mammals, turtles & birds - 5 coastwide aerial surveys, 2 coastwide shipboard surveys, 3 additional regional surveys ~103,300 km of survey effort

2. Via other types of surveys

- Harbor seal abundance survey photographed and tagged animals
- Two gray seal distribution and habitat usage surveys

3. Via tags

- USFWS Satellite-tagged Razorbills to monitor at-sea usage, movement patterns and migration paths

4. Via passive acoustics

- Deployed 15 bottom mounted passive acoustic recorders of baleen whales in 2013 and 2014.
- Examined North Atlantic right whale migratory corridors using archived passive acoustic data

5. Via the internet:

- Satellite-based (SST and chlorophyll) and dynamic model-based data (mixed layer depth, water temperature and salinity at depth)

Bias corrections to the density estimates

1. Perception bias:

- 2 independent team methods during NMFS shipboard and aerial surveys

2. Availability bias/Distribution/Ecology:

- Tagged about 120 loggerhead turtles with satellite tags
- Tagged 29 harbor seals
- Used DTAG data collected by other researchers in Atlantic and Pacific
- Deployed towed arrays during NMFS shipboard surveys to investigate deep diving whales and various dolphin whistles
- Used skeletochronology and stable isotopes to determine the length of time juvenile loggerhead turtles spend outside the survey area

3. Seabird studies by USFWS:

- Conducted detection study to quantify detection, availability bias, counting errors and misidentifications
- Developed analytical methods to account for highly aggregated bird flocks detected in surveys
- Developed analytical methods to account for the bird flocks not identified to species

Ecological and Biological studies

1. Health and biology:

- **Collected blood and other samples** from tagged loggerhead turtles, gray and harbor seals for demography and animal health

2. Ecological relationships:

- Shipboard surveys also **collected habitat and trophic biological data** using EK60 echosounder, bongo nets, visual plankton recorders, MOCNESS nets, Isaac-Kidd midwater trawls, beam trawls and bottom grabs, and XBTs and CTDs
- Temperature observations from turtle-borne sensors may help improve ocean models.

3. Behavior:

- Using a remotely operated vehicle (**ROV**) to **observe loggerhead sea turtle behavior** on mid-Atlantic foraging grounds
- In-situ behavior of Mid-Atlantic loggerheads.

Database development

1. **Developed Oracle database** for shipboard and aerial NMFS sightings and effort data, loggerhead turtle and seal satellite data, along with biopsy and photograph metadata, archived environmental data pulled from satellite and ocean model online databases
2. Developed **database capabilities** to
 - easily plot track lines, sightings, densities by grid cells
 - export data in formats needed for analysis methods
 - Export data to other databases like OBIS Seemap
3. Used database of sightings data and photographs to **develop a field guide** of cetaceans and to develop a species identification guide of sea turtles
4. Added seabird sightings and effort data to the **USGS marine bird compendium database**
5. Developed a **database to archive passive acoustic data**

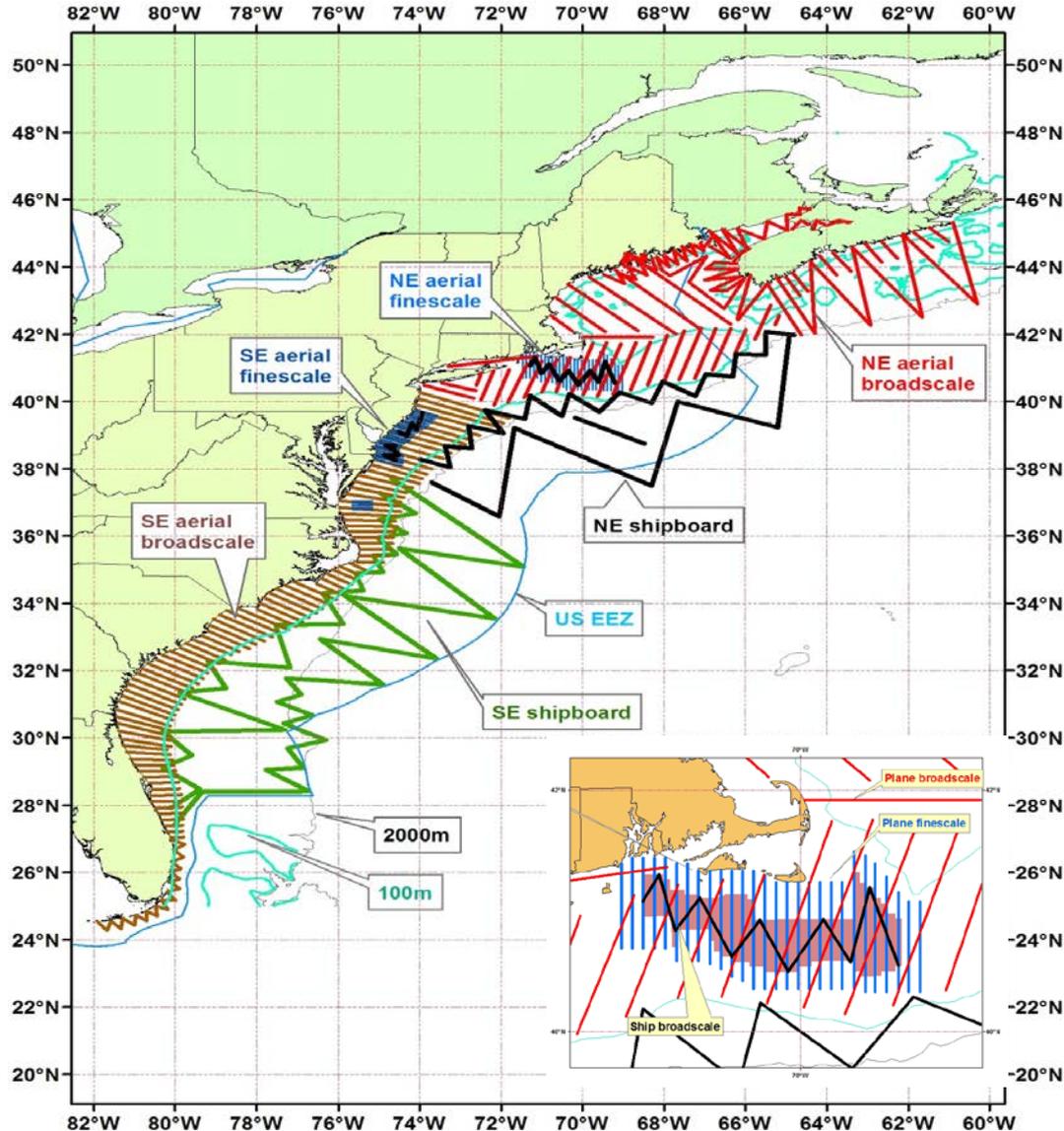


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Input data

- Line transect data from ships and planes
- Passive acoustic data
- Habitat and trophic data from ship surveys
- Habitat data from online databases

NMFS aerial and shipboard surveys



NOAA's Twin Otter and ship

NMFS aerial and shipboard surveys

Surveys:

2010: Jul-Aug

2011: Jan-Mar, Jun-Aug

2012: Mar-May, Sep-Nov

2013: Jul-Sep

2014: Feb-Apr, Jul, Dec

103,300 km of track lines

2 team line transect

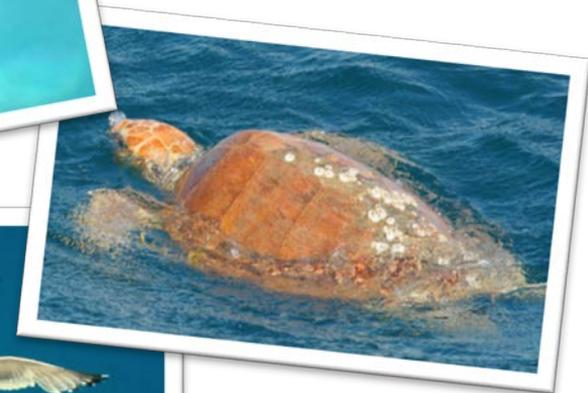
5400 cetaceans detected

5850 turtles detected

200 seals detected

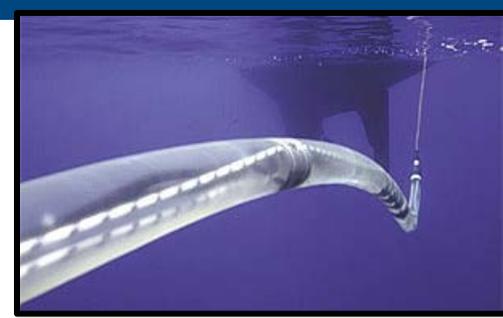
4100 seabirds detected

Regional cetacean and loggerhead
turtle abundance estimates
available



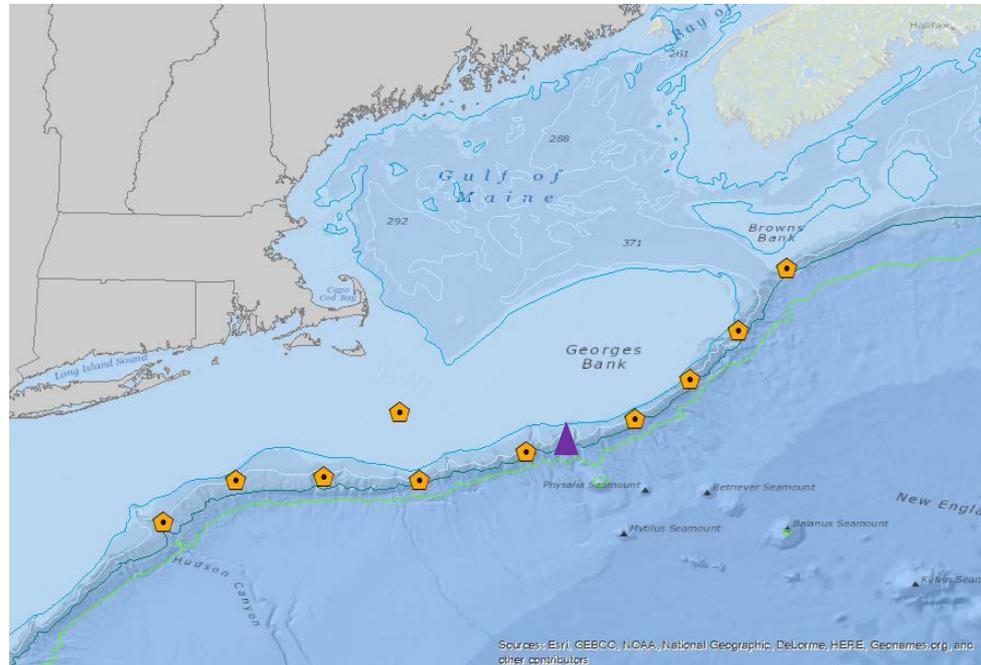


Passive Acoustics



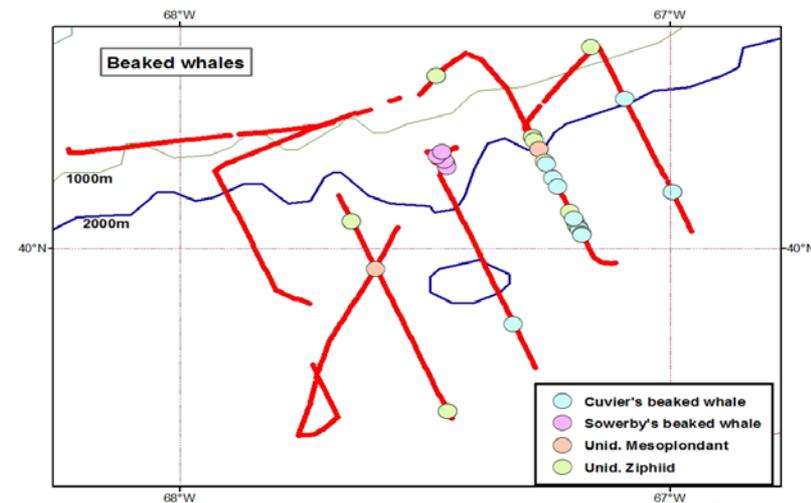
Bottom mounted recorders:

- MARUs and AMARs deployed and/or picked up during AMAPPS shipboard surveys



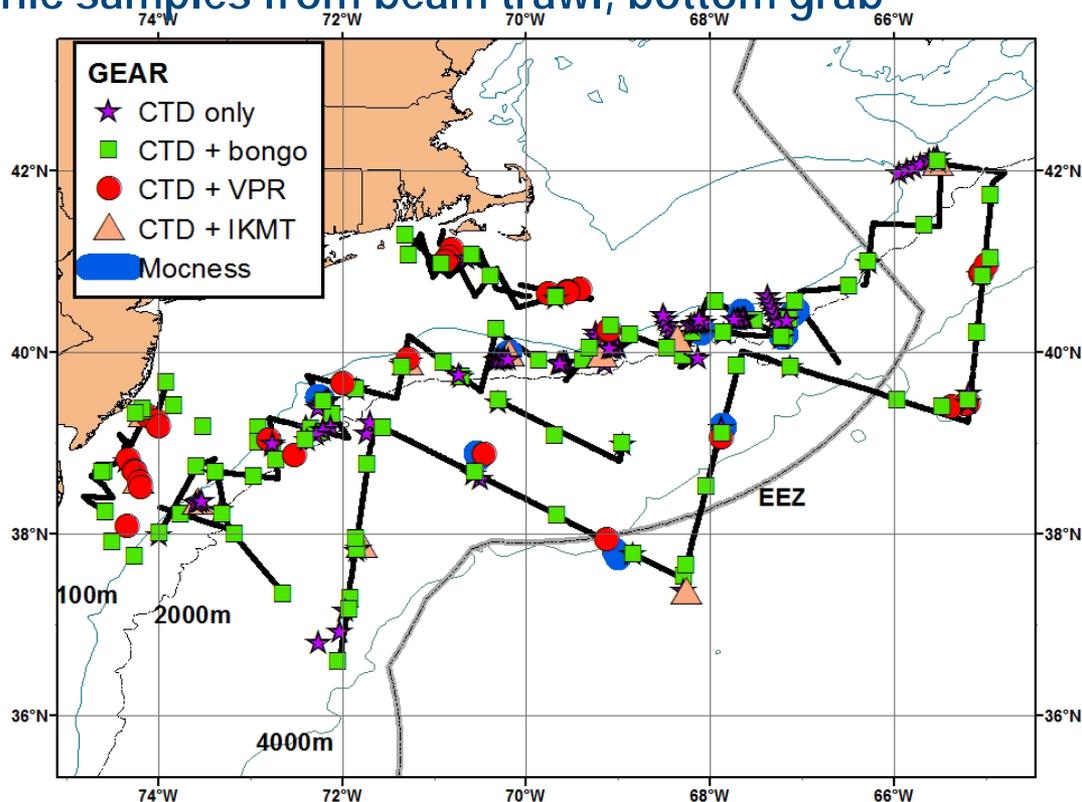
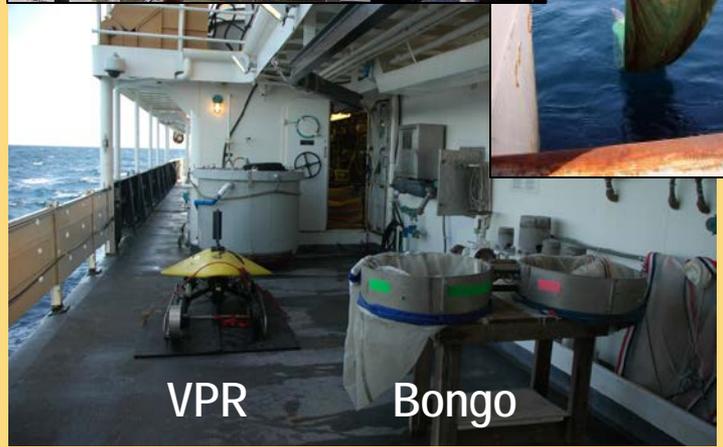
Towed arrays:

- Beaked whales
- Sperm whales
- Risso's dolphins
- ROCCA (dolphin whistle classifier)

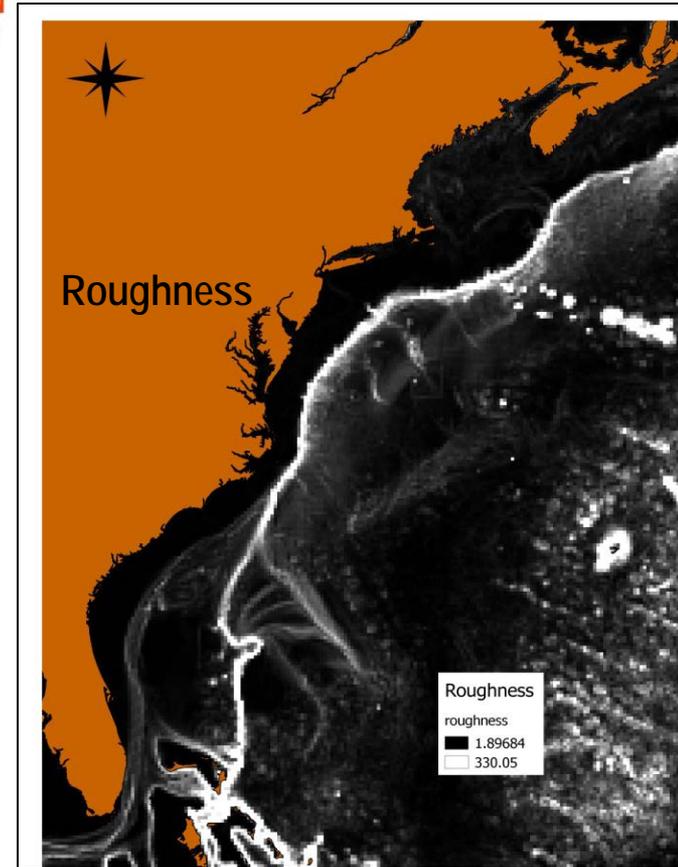
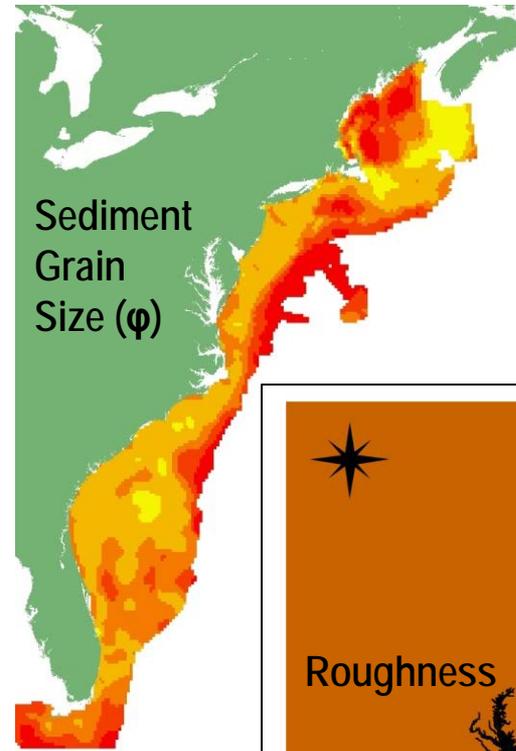
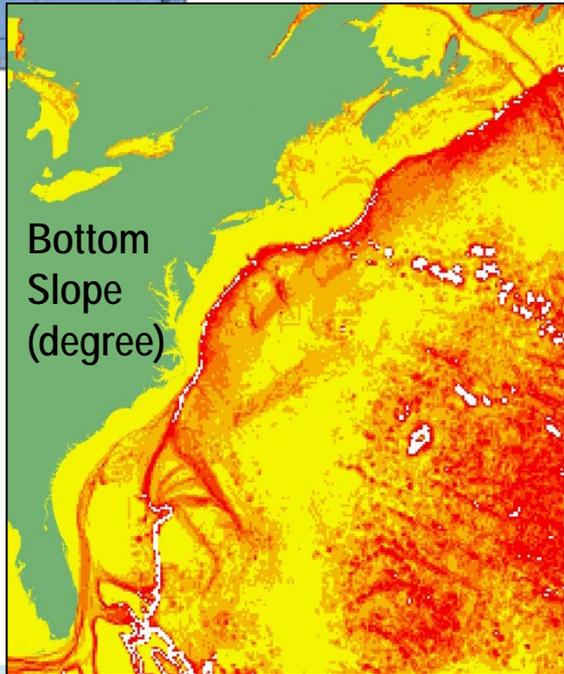
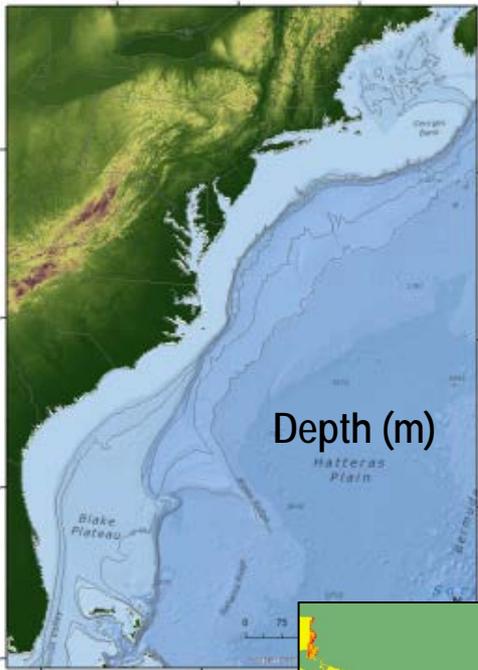


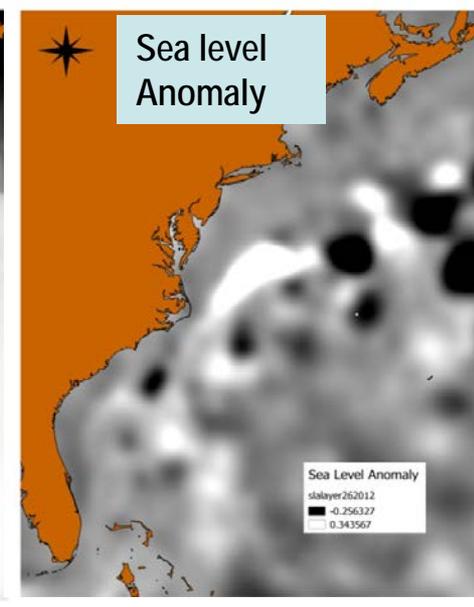
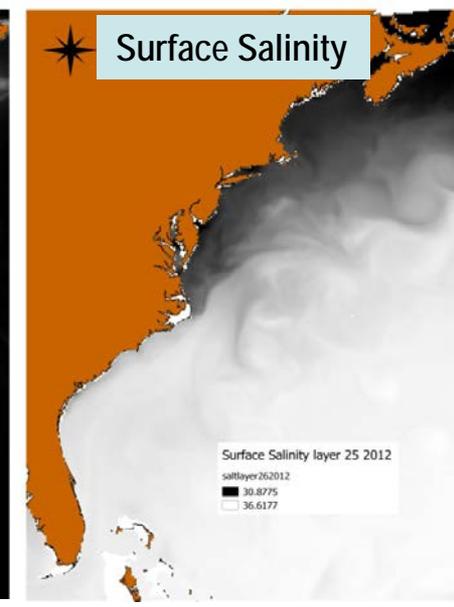
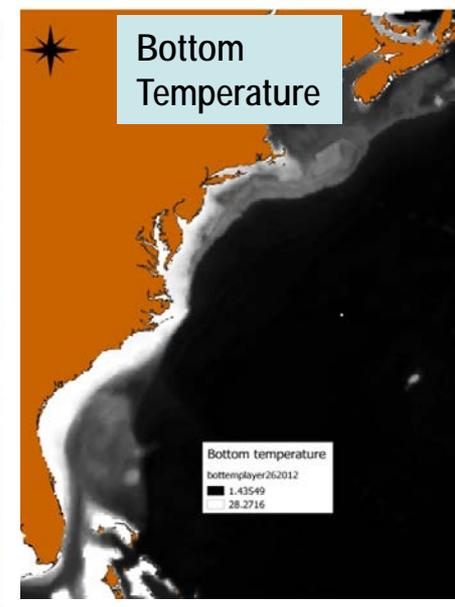
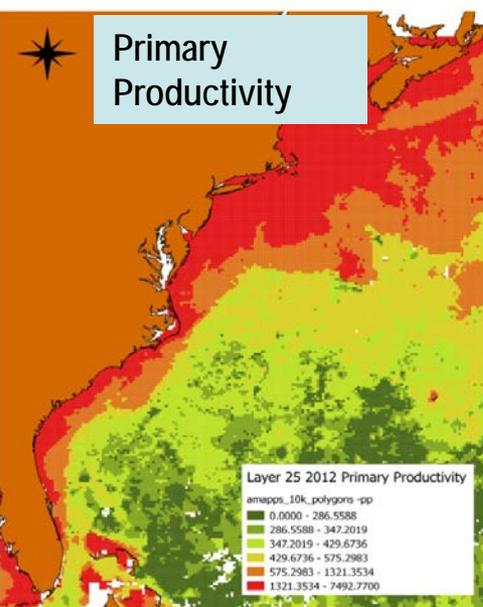
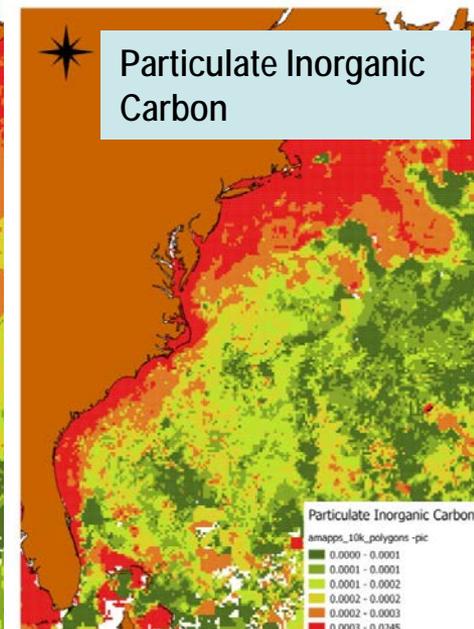
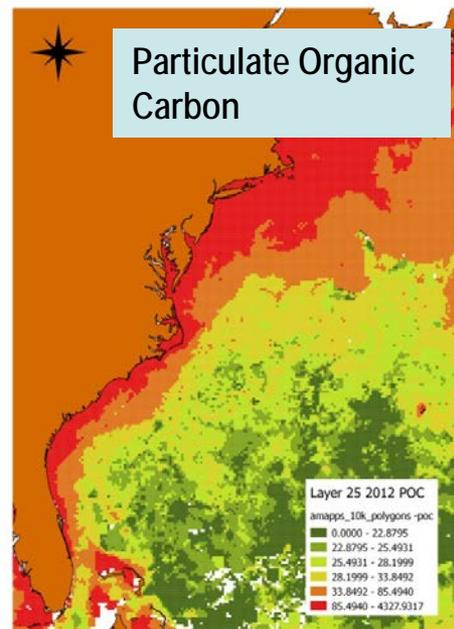
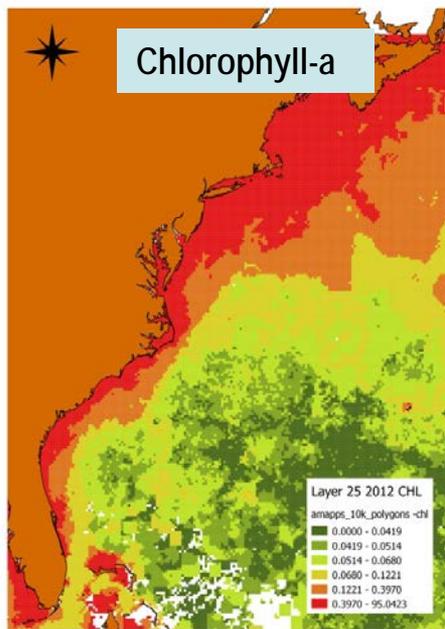
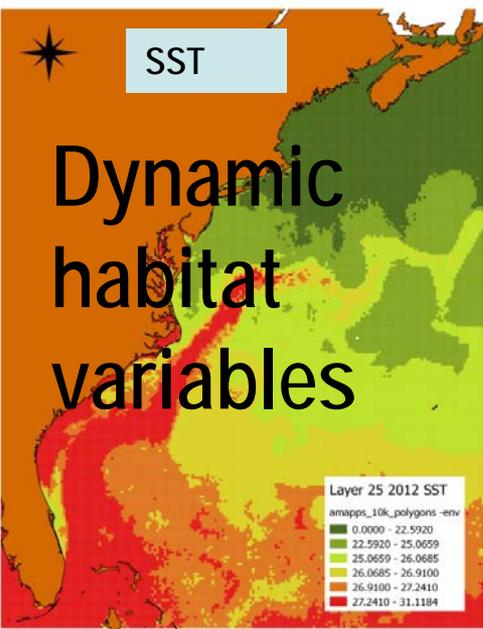
Habitat and trophic data

- Shipboard data collected simultaneously
 - EK60 backscatter data for plankton & fish
 - Plankton and macronekton samples from bongo nets, VPR, MOCNESS, Isaac-Kidd trawl
 - Benthic samples from beam trawl, bottom grab



Static habitat variables







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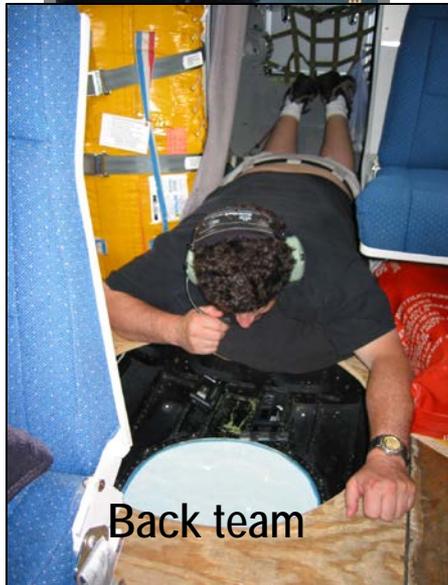
Addressing biases

- Perception bias – bias due to not detecting a group even though it is at the surface
- Availability bias – bias due to animals diving and so not able to be detected

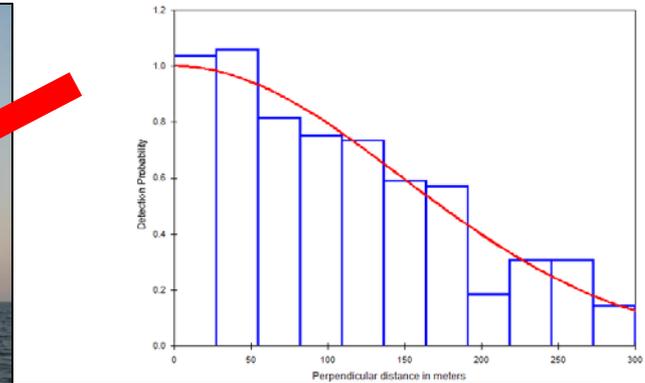
Perception bias accounted for in NMFS ship and plane surveys by using 2 or 3 “independent” platforms and mark-recapture distance analytical techniques to estimate $g(0)$



Front team



Back team



Upper team

Lower team

Availability bias of loggerhead turtles

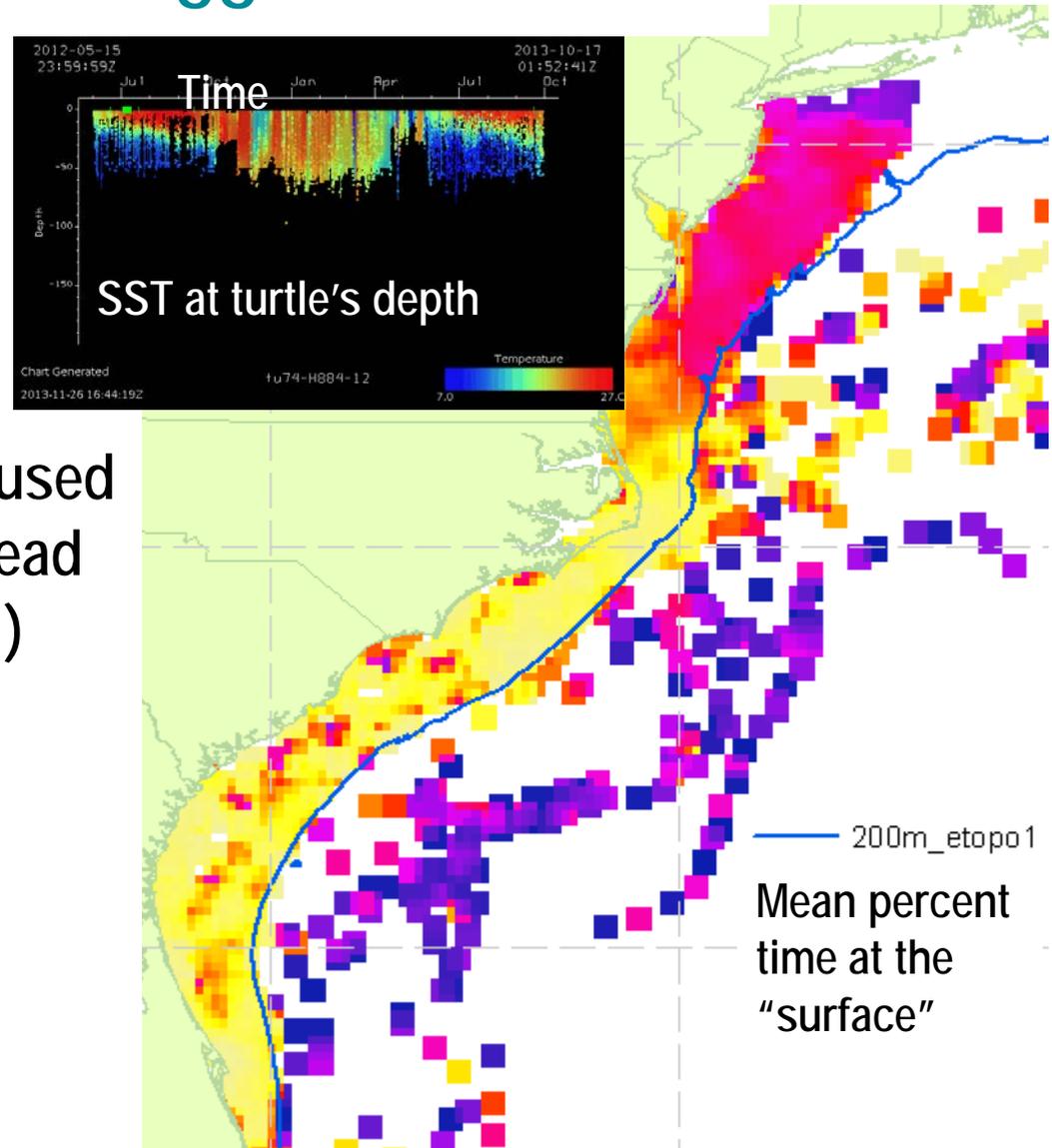
Loggerhead turtle tags

~120 AMAPPS tags deployed

~60 more from collaborators

2010 tag and aerial survey data used to estimate 800,000+ loggerhead turtles (NEFSC + SEFSC 2011)

Availability seen in the top 2 m attempted via collaborative project with Navy, CFF, VAQ, CREEM.

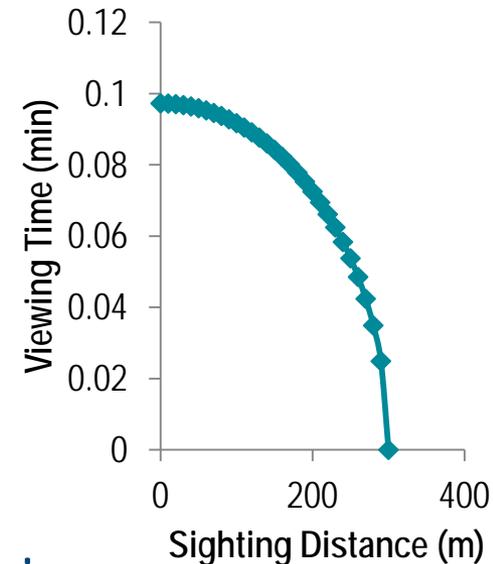


This map is intended to help meeting participants visualize the data. These results should not be used for science or management purposes. A formal report is in prep.

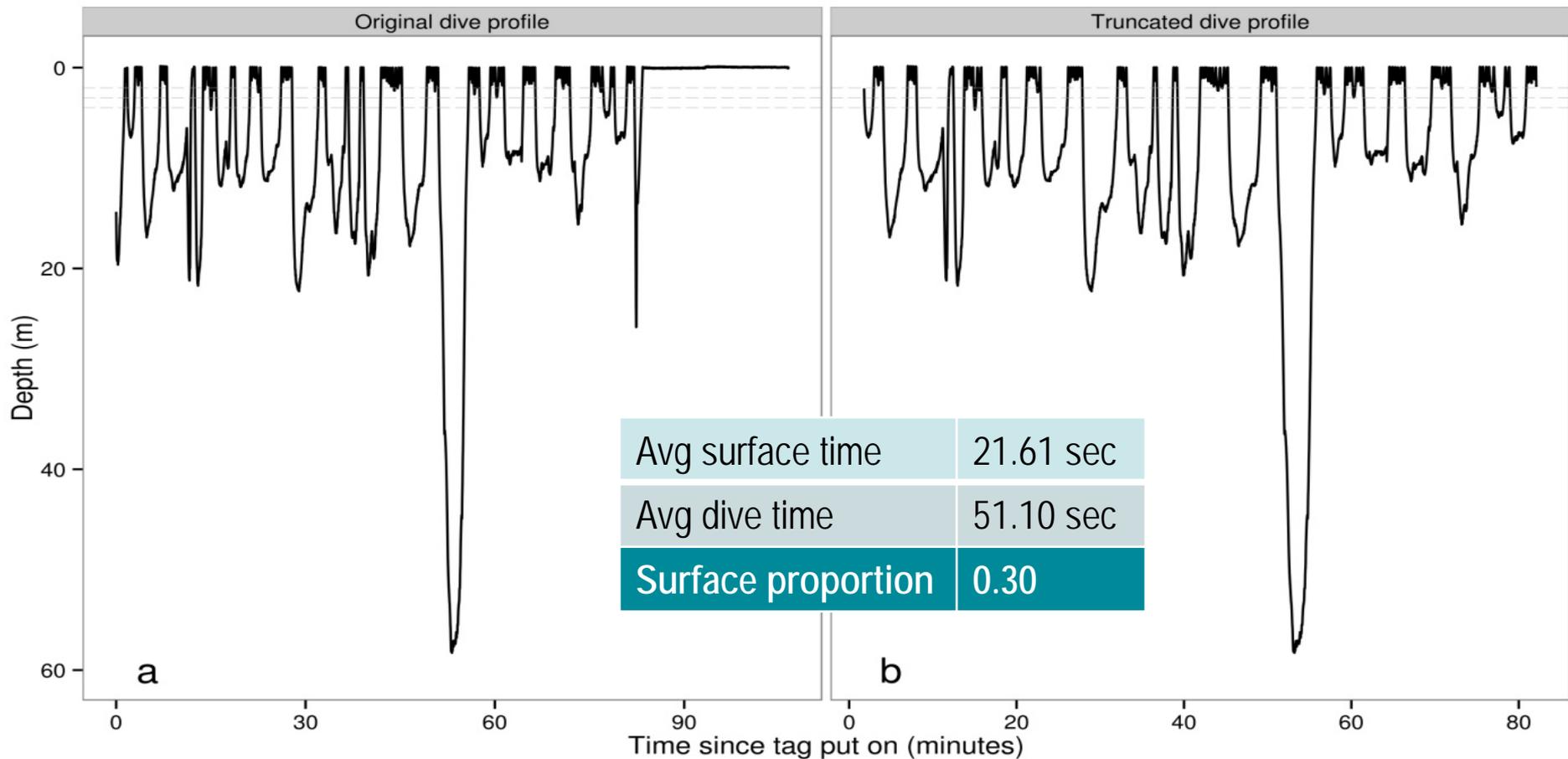
Cetacean availability bias



- Dtag data collected by others to investigate the amount of time at the surface and diving for the following species:
 - Humpback, fin , blue, right, and sperm whales, pilot whales, Risso's dolphins, beaked whales
- Extensive literature review to collate previously published estimates of surfacing and diving times.
 - 21 different species from around the world
 - Over 100 different references to times
- Data from aerial surveys to determine species specific fields of view.
- Shipboard data on dive patterns of small groups that can be analyzed using methods in Borchers et al. 2013



DTAG dive data from humpback whale off northeast U.S. Atlantic coast to get average surface and dive times to be used in availability bias correction





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Biological data

- Collected biological samples from loggerhead turtles and grey seals
- Investigating in-situ behavior

Tagging Lagniappe: Sex, Blood, and Stable Isotopes



Biological research

- Loggerhead turtle demography in US Mid-Atlantic, size, weight, condition, sex. (Collaborators: Barco, Allen, Haas, Owens, Schwenter, Smolowitz)
- Using a remotely operated vehicle (ROV) to observe loggerhead sea turtle behavior on foraging grounds off the mid-Atlantic United States. (Collaborators: Smolowitz, Patel, Haas, and Miller)
- In-situ behavior of Mid-Atlantic loggerheads. (Collaborators: Dodge, Haas, Matzen, Miller, Patel, Smolotwitz)



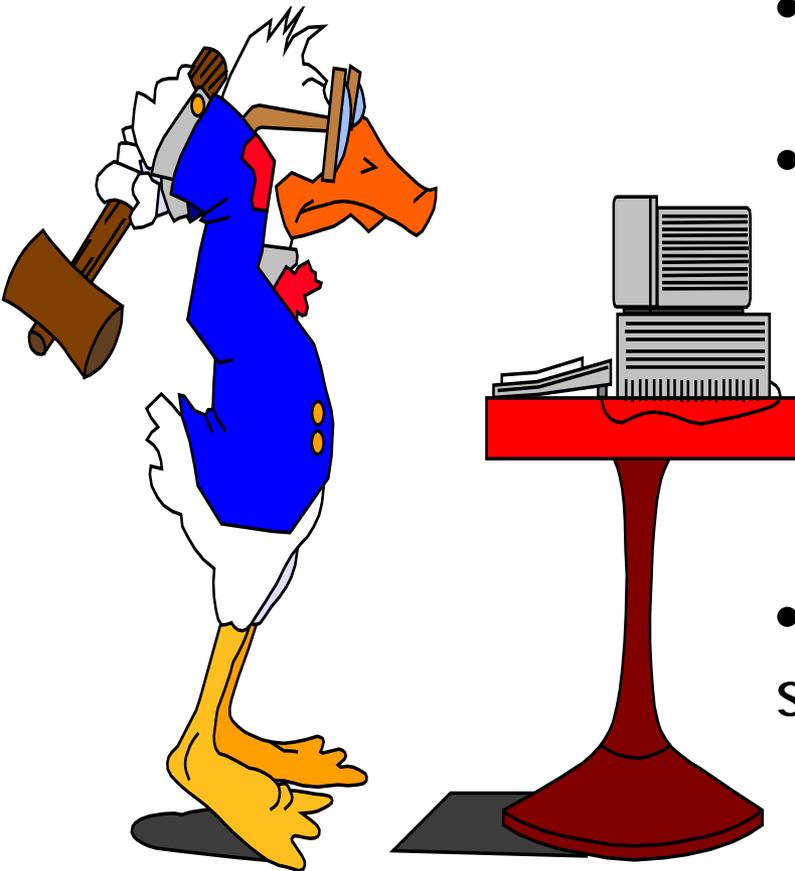
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Analytical methods

- Mark recapture distance sampling
- Spatially-explicit habitat models
- Integrating trophic level data into models
- Future analyses

After collect data ... previously ...

Used mark-recapture distance sampling To estimate abundance



- Implicitly includes estimate of $g(0)$
- Two sub-model components
 - Detection function
 - Probability one team detected a group, when the other team has detected it
- Use covariates to better describe these sub-models

From: Palka 2012. Northeast Fish Sci Cent Ref Doc. 12-29.

Now ... also modeling habitat seasonal density estimates



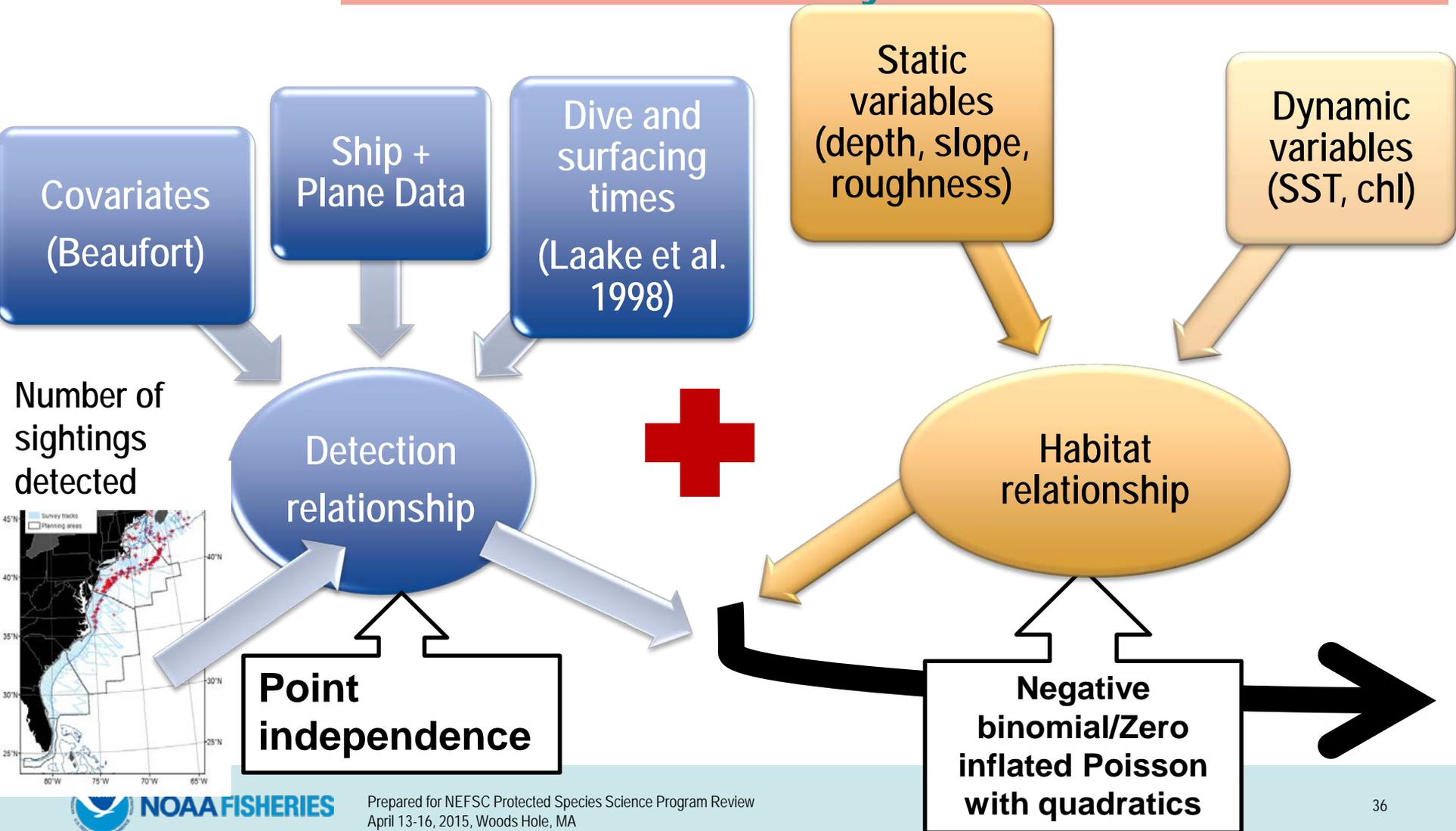
- ❑ **Bayesian hierarchical models**
- ❑ **Generalized linear and additive models**

Multiple methods allow comparison of methods, development of best method for each species, model averaging since each method has its pros and cons

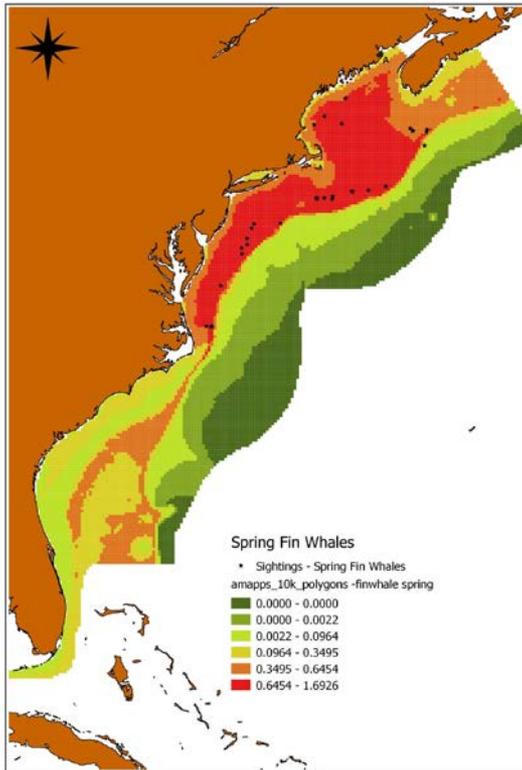
Goals:

- 1) Produce spatially-explicit seasonal density maps that incorporate habitat variables
- 2) Estimate population abundance
- 3) Quantify uncertainty
- 4) Forecast future distributions

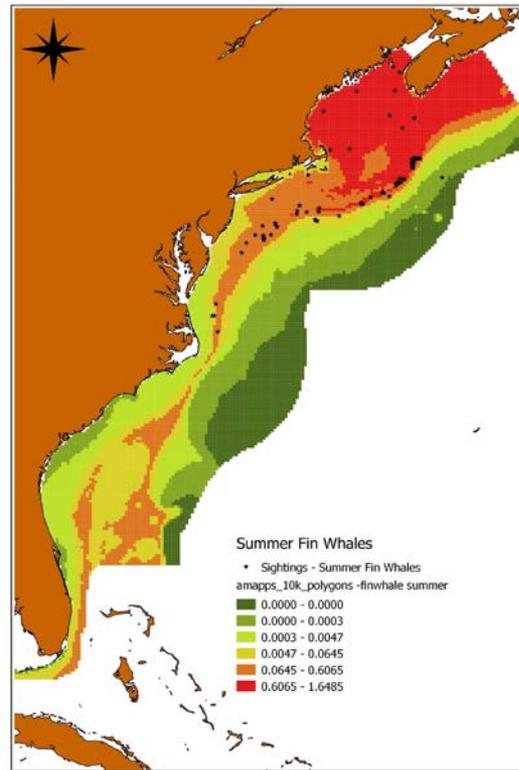
Integrating habitat variables into Bayesian Hierarchical density models



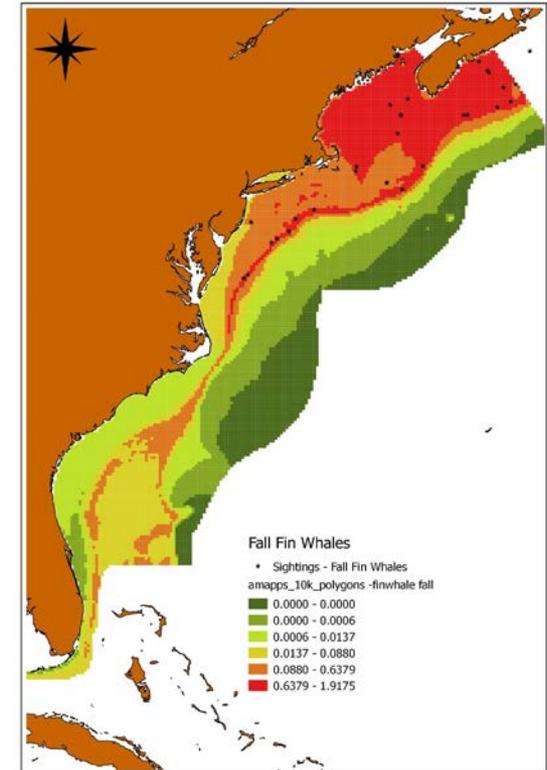
Preliminary fin whale seasonal maps



Spring

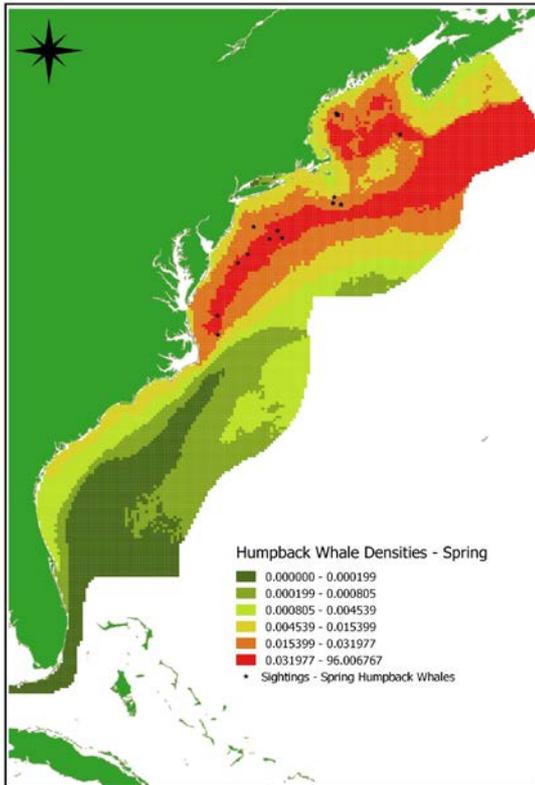


Summer

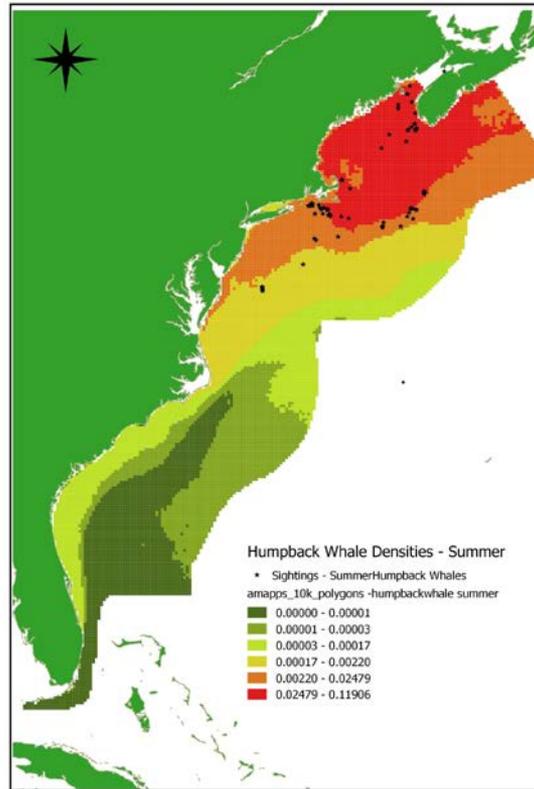


Fall

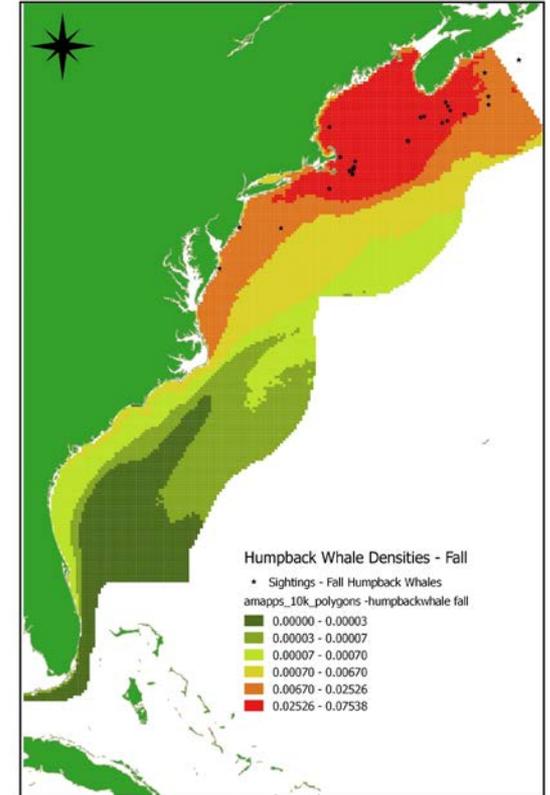
Preliminary humpback seasonal maps



Spring

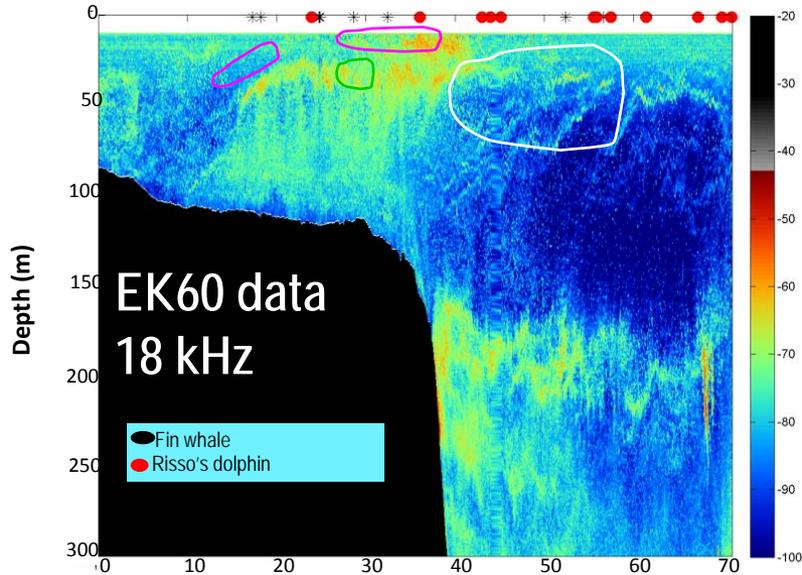


Summer

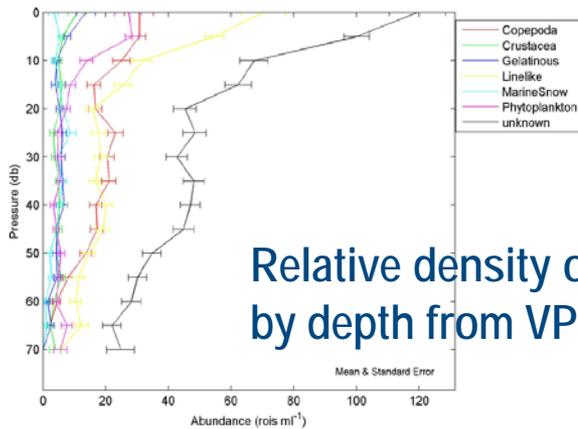


Fall

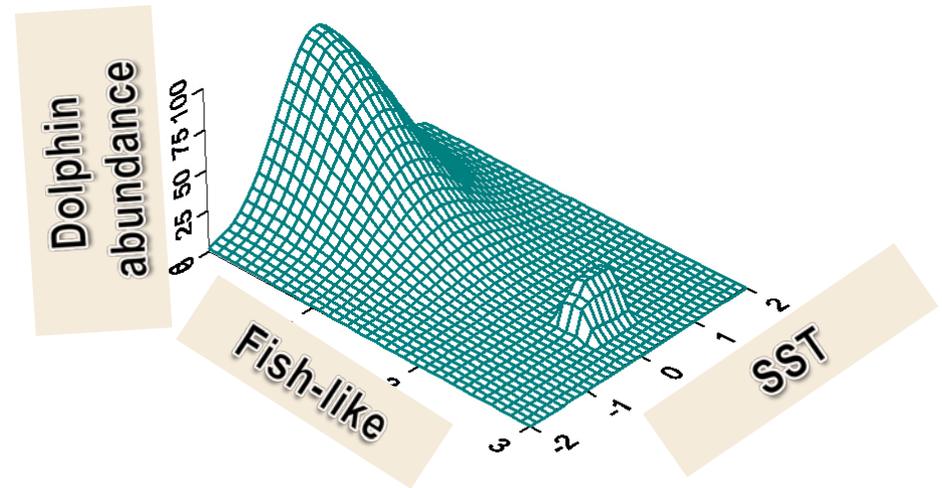
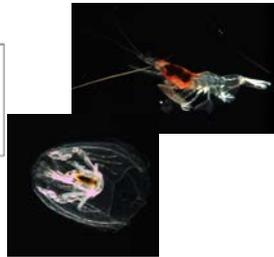
Integrating distributions of lower trophic levels with the cetacean distributions



1. Process EK60, VPR, and marine mammal data types



Relative density of plankton types by depth from VPR



2. Describe nonlinear relationships and account for spatial autocorrelation.

Future work using seasonal distribution models

- Investigate trends over years and seasons
- Overlay with seasonal distributions of threats
- Investigate changes related to environmental (climate) changes
- Inform ecosystem models, population viability analyses and other types of assessments
- Predict into the future, distribution patterns, risks to threats, etc (given lots of the usual caveats)

Data sharing

- Sharing cetacean shipboard & aerial survey data with:
 - OBIS-SEAMAP
 - OBIS-USA
 - Navy/Duke
 - NROC/Duke
 - BOEM
- Sharing shipboard seabird data with NOAA Biogeography
- Sharing passive acoustic data with the national TETHYS database and other institutions
- Sharing seal samples and tag data with a variety of institutions

Reviews

- Journal papers were peer reviewed
- Abundance estimates and AMAPPS work reviewed annually by Atlantic Scientific Review Group
- All Stock Assessment Report updates vetted by public and released annually
- Density modeling techniques reviewed during a webinar Feb 26, 2015 with 20 reviewers providing verbal and written comments

Strengths

- Coordinating within NEFSC and across SEFSC, USFWS, BOEM, US Navy and other partners in an integrated program (in fact could not have done the work without these collaborations)
- Excellent partnership with industry and academics on sea turtle tagging and ecological work
- Received ship and aerial platform support from NMFS
- Now collecting more distribution data from non-summer seasons for the last 5 years, with more to come
- Extensive loggerhead turtle tag dataset
- Developing and improving analytical methods to estimate abundance using line transect data and to model spatial and seasonal densities

Challenges

- Need more biopsies for stock structure
- Need more data for availability bias for a variety of deep divers and cryptic cetaceans
- Even with all the loggerhead turtle tag data for availability correction, patterns are complicated & challenging
- Prediction of future distribution and abundance patterns
- Estimation of past and future trends
- Incorporation of protected species information into ecosystem models and more complicated assessment models for fish, marine mammals and sea turtles.
- **Program relies extensively on external funding and contract field and analytical staff**

Solutions/Recommendations

- Continue multi-agency partnerships to support and execute AMAPPS
- Conduct dedicated surveys to collect more biopsies and cetacean tag data (starting with sperm whales)
- Compare density models and results with other similar efforts by NMFS and partners
- Continue developing methods to utilize different types of data (line transect, tagging, passive acoustic, bycatch, etc) to document seasonal and trends in distribution and abundance patterns
- Use baseline data and results from AMAPPS to inform assessments of impacts from human activities, environmental changes, etc.