Patterns of cetacean species occurrence, distribution and density at three sites along the continental shelf break of the U.S. Atlantic coast

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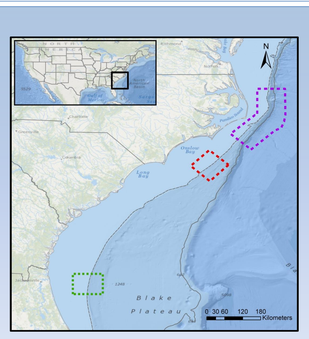
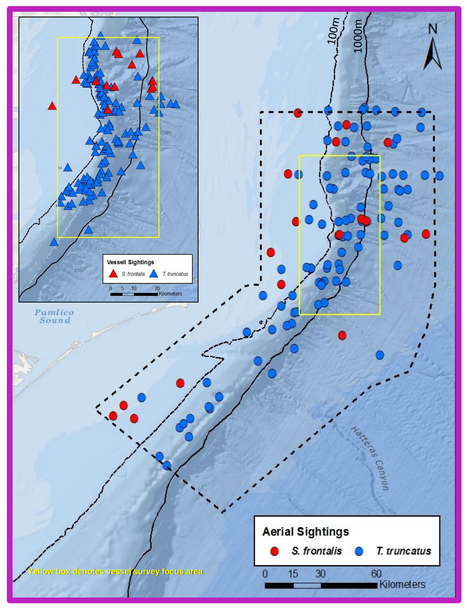


ABSTRACT

As part of the U.S. Navy's Integrated Comprehensive Monitoring Program in support of Atlantic Fleet Testing and Training, we are monitoring the occurrence, distribution and density of cetaceans at three offshore sites along the U.S. Atlantic coast. We are using an identical suite of survey methods (line transect surveys, photo-identification, biopsy sampling and passive acoustic monitoring) at each 500nm^2 reference site. Surveys began in Onslow Bay, NC in 2007, Jacksonville, FL in 2009 and Cape Hatteras, NC in 2011. To date we have conducted 48674km, 60687km, and 14213km of aerial surveys with 6883km, 3422km and 2443km of vessel surveys and 1201 days, 1264 days and 28 days of High-frequency Acoustic Recording Package (HARP) recordings at Onslow, Jacksonville and Cape Hatteras, respectively. In both Onslow and Jacksonville, the cetacean fauna is dominated by *Tursiops truncatus,* with densities of 0.034/km^2 and 0.025/km^2 respectively and *Stenella frontalis,* with densities of 0.027/km^2 and 0.045/km^2 respectively. *S. frontalis* was encountered exclusively over the continental shelf. *Grampus griseus* and *Globicephala macrorhynchus* were the most commonly encountered pelagic odontocetes at these two sites. Species richness is much greater at Cape Hatteras than at the two southern sites (with 18 species sighted at Cape Hatteras, 10 at Jacksonville and 9 at Onslow), with the inclusion of several boreal species during colder months and the common occurrence of several deep-diving odontocetes, including *Physeter macrocephalus*, *Ziphius cavirostris* and *Mesoplodon* spp. Mysticetes, including *Balaenoptera acutorostrata*, *B. physalus, Eubalaena glacialis,* and *Megaptera novaeangliae*, were encountered only during winter at all three sites. In addition, we have detected the calls of two species on bottom-mounted HARPS that were not observed during visual surveys, including *B. musculus* and likely *B. borealis*. We highlight the particularly high diversity of cetaceans at the Cape Hatteras shelf break and suggest that this is a hotspot of species richness in the North Atlantic.

Distribution and Abundance of *Stenella frontalis* and *Tursiops truncatus*

Study Areas



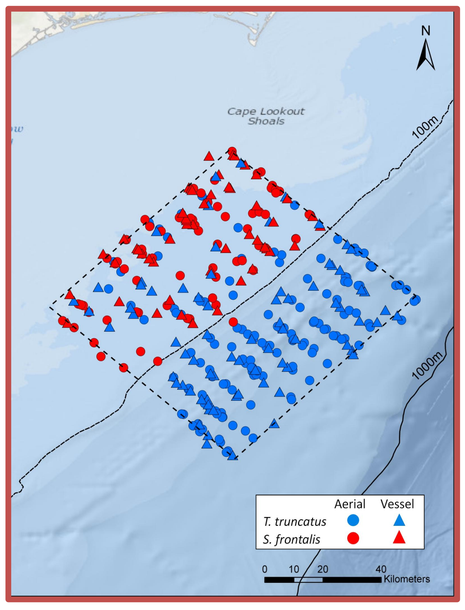
- Hatteras surveyed from 2011
- Jacksonville surveyed from 2009
- Onslow Bay surveyed from 2007

- Effort at each site has included monthly aerial line transect surveys, vessel line transect surveys, biopsy sampling and photo-ID

- Monthly aerial surveys, photo-ID and biopsy sampling are ongoing in Cape Hatteras and Jacksonville

- Jacksonville site is offshore of North Atlantic right whale (*Eubalaena glacialis*) nursery grounds (Foley *et al.* 2011) and is the site of the US Navy's planned Undersea Warfare Training Range

Cape Hatteras, NC



- Bottlenose dolphins and Atlantic spotted dolphins dominate the cetacean fauna in both Onslow Bay and Jacksonville

- Both species also occur in Hatteras, although the diversity of cetacean fauna at this site is much greater (see below)

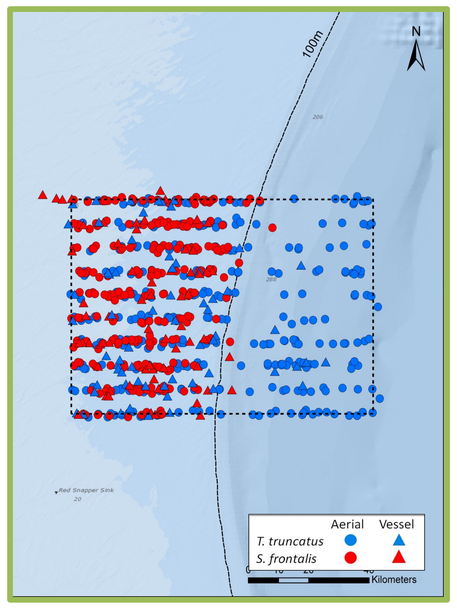
- In Jacksonville and Onslow (the two southern sites), spotted dolphins are found exclusively over the continental shelf; in Hatteras this species is found over both shelf and more pelagic waters

- At all three sites bottlenose dolphins are cosmopolitan

Density Estimates
T. truncatus 0.055/km^2
S. frontalis 0.082/km^2

Platform	Months	Days	Kilometers
Aerial	14	25	14213
Vessel	10	33	2443

Onslow Bay, NC



- Biopsy sampling of bottlenose dolphins at all three sites reveals that this species is represented exclusively by the offshore ecotype, even over shelf waters (see Swaim *et al.* poster)

- In Onslow and Jacksonville, spotted dolphins appear to be exclusively the relatively large-bodied form; in Hatteras the small-bodied, pelagic form of this species also occurs

- Estimates of density of the two species are similar in Onslow and Jacksonville, but higher in Hatteras

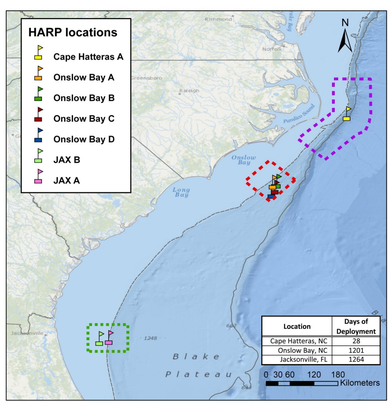
Density Estimates
T. truncatus 0.034/km^2
S. frontalis 0.027/km^2

Platform	Months	Days	Kilometers
Aerial	43	90	48674
Vessel	42	90	6883

Density Estimates
T. truncatus 0.025/km^2
S. frontalis 0.045/km^2

Platform	Months	Days	Kilometers
Aerial	38	94	60688
Vessel	18	45	3422

Acoustic Detections *vs.* Visual Detections



Species	Cape Hatteras, NC			Onslow Bay, NC			Jacksonville, FL		
	HARP	Aerial	Vessel	HARP	Aerial	Vessel	HARP	Aerial	Vessel
Eubalaena glacialis				Y				Y	
Megaptera novaeangliae		Y	Y	Y	Y		Y	Y	
Balaenoptera acutorostrata	Y	Y		Y	Y		Y	Y	
Balaenoptera borealis				Y			Y		
Balaenoptera musculus				Y					
Balaenoptera physalus	Y	Y	Y	Y	Y		Y		
Physeter macrocephalus	Y	Y	Y	Y				Y	
Kogia spp.	Y	Y		Y				Y	
Ziphius cavirostris	Y	Y	Y						
Mesoplodon spp.	Y	Y							
Steno bredanensis		Y			Y	Y		Y	
Tursiops truncatus		Y	Y		Y	Y		Y	Y
Stenella frontalis		Y	Y		Y	Y		Y	Y
Stenella longirostris		Y							
Stenella clymene		Y							
Stenella coeruleoalba		Y							
Delphinus delphis		Y	Y		Y				
Lagenodelphis hosei		Y							
Grampus griseus	Y	Y	Y	Y	Y	Y	Y	Y	Y
Peponocephala electra		Y							
Globicephala macrorhynchus		Y	Y		Y	Y		Y	Y
Total Species Recorded	7	18	9	9	9	5	5	10	4

Cape Hatteras, NC

- Results from a single HARP deployment (28 days)

- HARP detected subset of species observed by other platforms, and frequently detected beaked and sperm whales (see Stanistreet *et al*. poster)

- Placement in deeper waters may have influenced species detected

Onslow Bay, NC

- Multiple shallow and deep water deployments (1201 days)

- HARP detected subset of species observed by other platforms and detected five cetacean species not observed by other platforms

- Winter detections of several species of mysticete whales

Jacksonville, FL

- Multiple shallow and deep water deployments (1264 days)

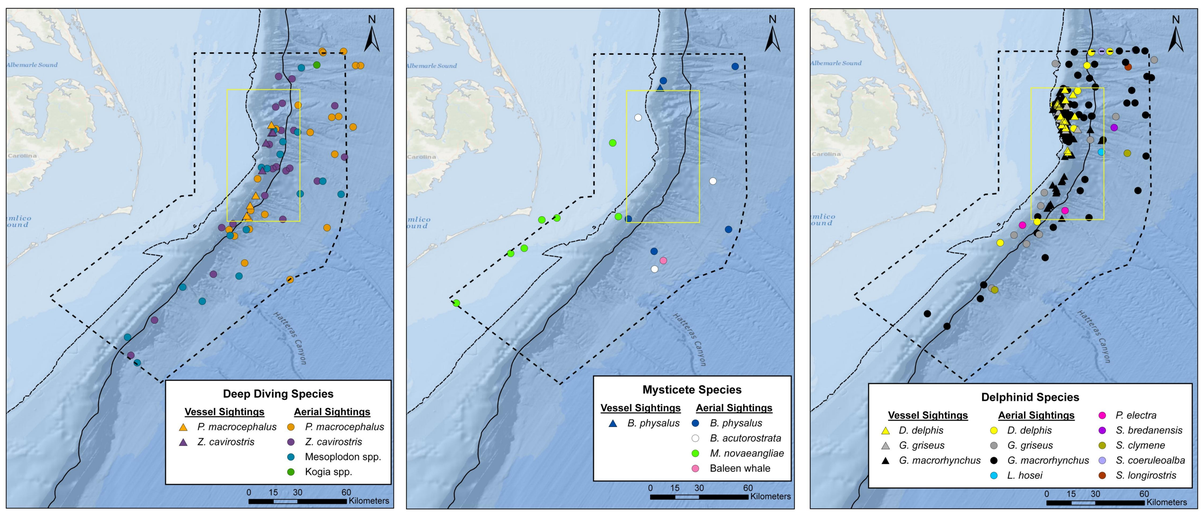
- Acoustic detections of two mysticete species not observed by other platforms but not North Atlantic right whales

- Significant background noise at the shallow water site may account for low species detection

Future Directions

Future baseline monitoring efforts will focus on the Jacksonville and Hatteras sites. Jacksonville is the US Navy's planned location for its Undersea Warfare Training Range. Intensive aerial, vessel and acoustic monitoring of this site will occur through the construction and implementation phases. Monitoring will also continue at Cape Hatteras, because of its high levels of cetacean density and diversity. Seasonal monitoring efforts will also continue in Onslow Bay to better understand patterns of residency and population structure of spotted and bottlenose dolphins.

Cape Hatteras Diversity

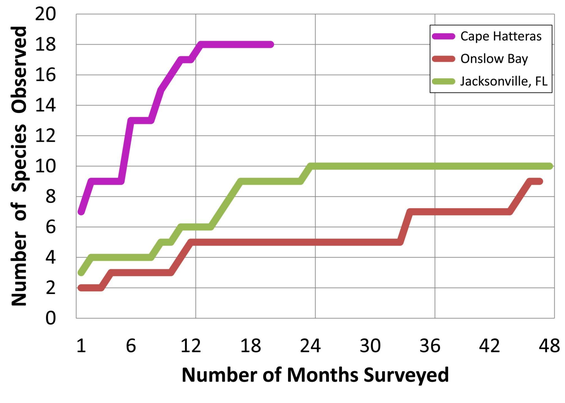


- The diversity and density of cetaceans at Cape Hatteras is considerably greater than that at the other two sites

- Cape Hatteras appears to be a particularly important area for cetaceans in the Northwest Atlantic, perhaps because of the confluence of the Gulf Stream and Labrador Current over the shelf break

- The year-round occurrence of deep-diving cetaceans in Hatteras is of particular interest with respect to Navy training activities and potential future seismic exploration activities

Comparative Cetacean Discovery Curves



In the first year of surveys, three times more species were observed at the Cape Hatteras site than at any other site.

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