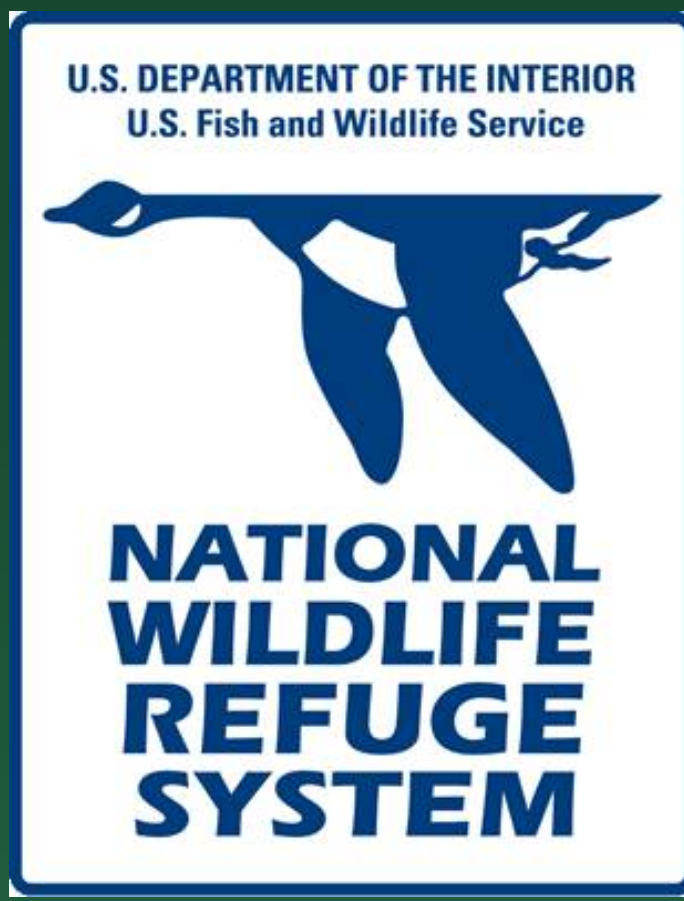




Using Seabirds to Track Ecosystem Change in the Gulf of Maine



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Background:

For the past 30 years, Maine Coastal Islands NWR, National Audubon Society, and Maine Department of Inland Fisheries and Wildlife have documented annual population levels, productivity rates, diet composition and feeding rates on 11 managed seabird colonies in Maine. While extensive data has been collected at the colonies, we know very little about the at-sea ecology of birds in the Gulf of Maine. While seabird must return to land to raise their young, they spend the majority of their time at sea foraging for themselves and their chicks. As a result, seabirds are intimately linked to physical and biological characteristics of marine ecosystems. Seabirds need persistent aggregations of prey to be located within commuting distance of their breeding colonies. Recently, seabird managers have observed what appear to be significant changes in forage fish abundance and availability for breeding seabirds. Several colonies have abandoned or experienced complete reproductive failure due to lack of available forage fish. We have also observed declines in chick growth and productivity rates. Seabirds are more easily observed, counted, and studied than other marine organisms and changes in ecosystem function should be evident in these upper trophic level predators.

The nine examples to the right show MCINWR Inventory & Monitoring efforts on the managed seabird colonies. We use this data to inform management decisions and evaluate progress towards our objective of maintaining healthy and productive seabird colonies.



We believe that our long-term monitoring efforts at the breeding colonies provide critical evidence that the productivity of the Gulf of Maine has significantly decreased in recent years. We are currently collaborating with several integrated ecosystem based projects to ensure that seabirds remain a viable component of the Gulf of Maine ecosystem.

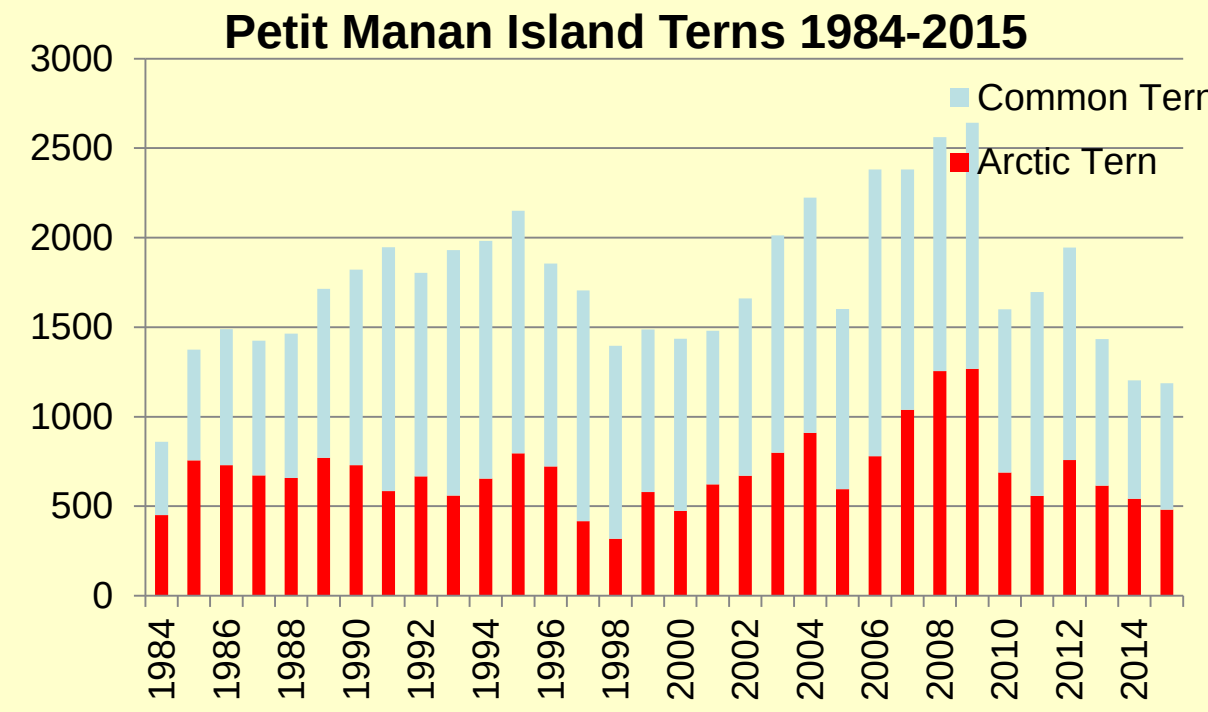


Colonies in Maine

Species	# Breeding Pairs	# Colonies
Roseate Terns	200	3
Arctic Terns	2,400	7
Common Terns	9,065	14
Atlantic Puffin	Est 1,000	5
Laughing Gull	2,563	3
Razorbill	650+	6
Great Cormorant	72	5
Double Crested Cormorant	9,510	81
Herring Gull	21,488	180
Great Black-Backed Gull	6,934	183
Common Eider	21,000	320
Black Guillemot	12,000 adults	166
Leach's Storm Petrel	10,370	33

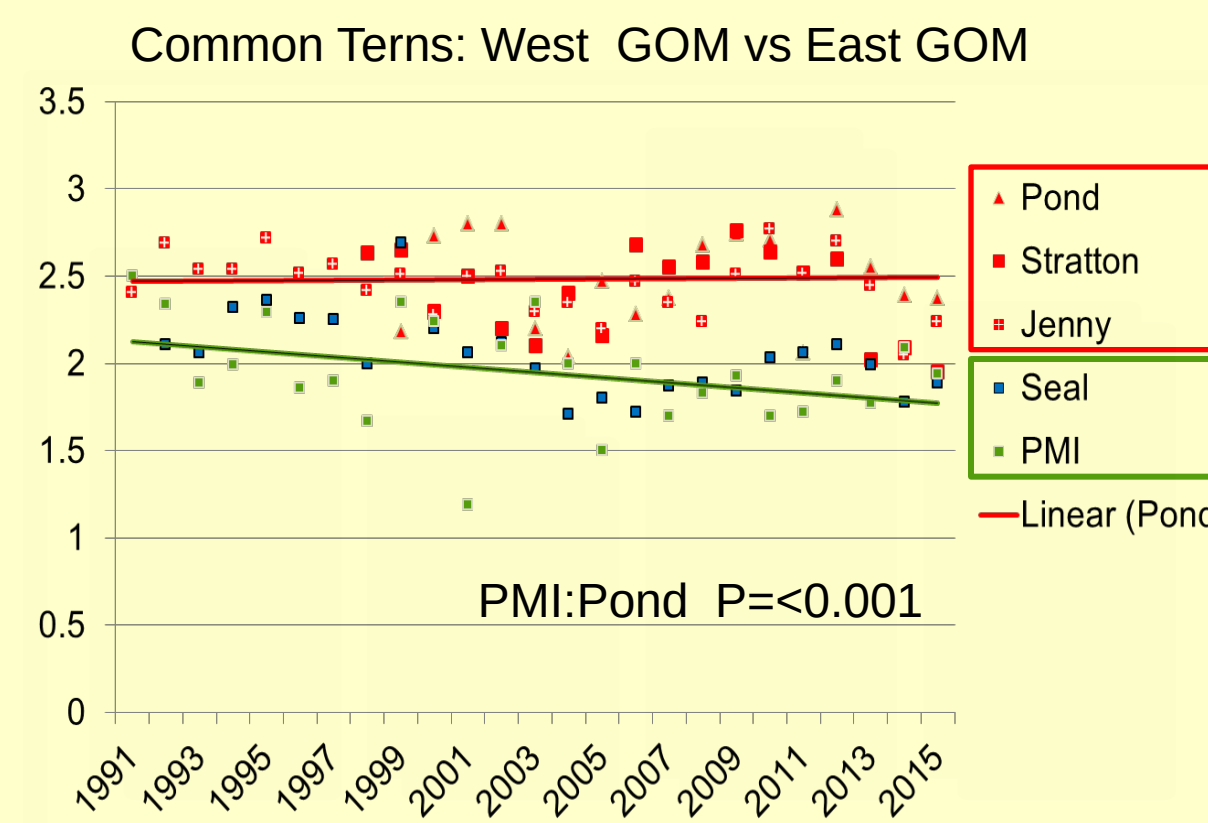
- Within Maine, 99% of common and Arctic terns, and all roseate terns nest on 11 managed islands.
- Within the US, 90% of Atlantic puffins nest on 3 MCINWR islands
- Within the US, 85% of razorbills breed on 4 MCINWR islands
- Within Maine, 92% of the federally endangered roseate terns breed on only 2 islands

Colony Size



- The PMI tern colony has decreased 30% in the past 5 years despite predator control and vegetation management. Tern productivity has also been very low during this period.
- In the GOM, Arctic terns have declined by 50% in the past 10 years.

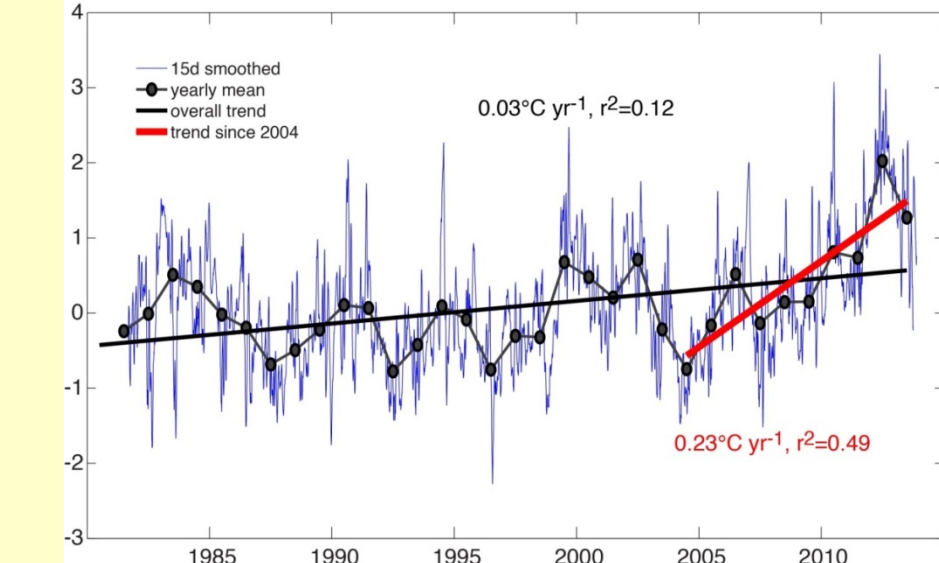
Clutch Size



- Average clutch size has decreased significantly for terns nesting in the eastern portion of the Gulf of Maine (as compared to the western GOM)
- We believe this reduction is due to a decline in the quality and abundance of forage fish in this region

Climate Change & Weather Events

Gulf of Maine Sea Surface Temperature



- GOM has been warming for decades, but rate of warming increased significantly in 2004
- 2013 was the warmest year on record
- GOM is warming faster than 99.9% of oceans around the globe

Environmental Monitoring

- MCINWR is collecting precipitation, wind speed, and temperature data at all of the managed colonies
- We are also utilizing data collected by our partners: Sea Surface Temperature, Sea Level Rise, GOM productivity, and currents
- The increasing frequency and intensity of storms has resulted in inundation of nesting areas, egg and chick loss, and contributed to excessive plant growth on the colonies (reduces suitability for nesting)



Healthy & Productive Seabird Colony

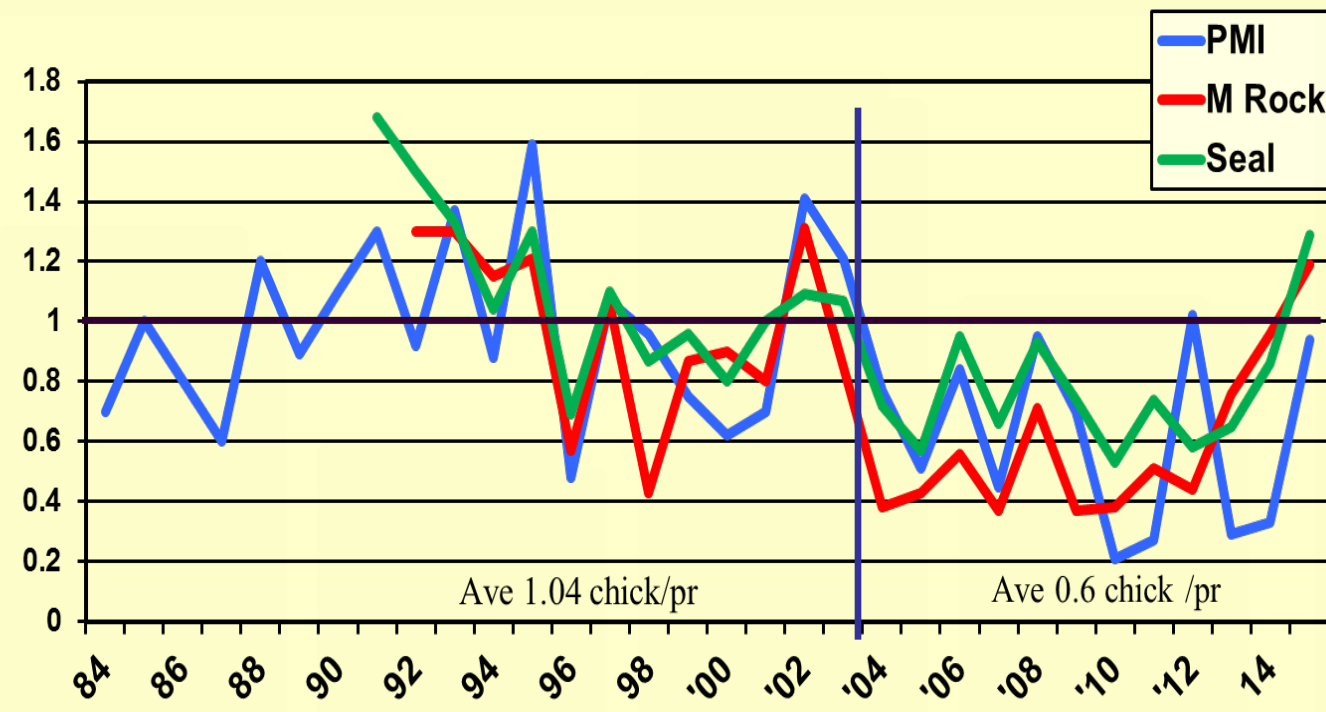
Predator Control

- MCINWR is working to reduce the number of laughing gulls breeding on Petit Manan. Since 2008, the population has been reduced by 55% through a combination of egg and nest destruction and lethal control
- We prevent great black-backed and herring gulls from nesting on the managed colonies
- We maintain active mink and great horned owl trapping programs on several islands

Seabird Productivity

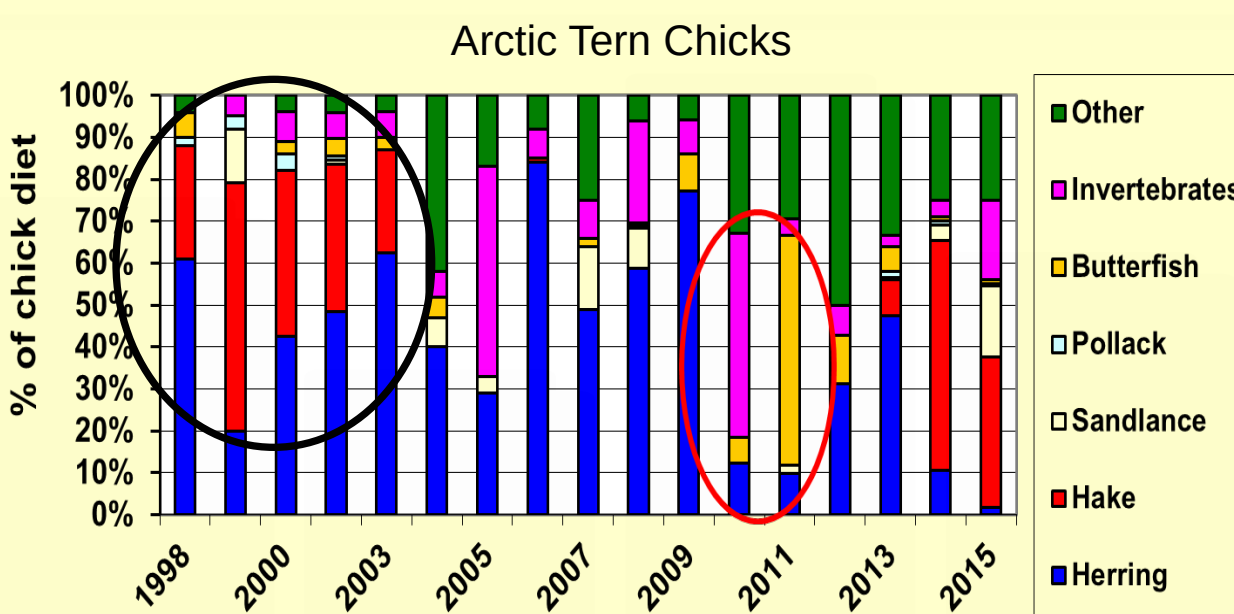
Arctic Tern Chick Productivity (chicks / pair) (Petit Manan, Matinicus Rock, and Seal Islands)

- Productivity rates for Arctic terns nesting on all 3 colonies decreased significantly between 2004 and 2014. Target productivity levels are 1 chick / pair.
- Adult terns were often unable to find sufficient forage fish to feed their chicks, resulting in mass starvation at colonies.
- This event was correlated with a decrease in overall productivity of the Gulf of Maine.



P values range from 0.02 – 0.0008

Diet Composition



- Herring and Hake were the predominant diet items prior to 2004 (black circle). Hake was not available for the next 10 years.
- In very poor food years (red circle), terns fed their chicks invertebrates and butterfish (too large to swallow).
- As a result, many tern chicks starved to death in 2010 /11. Arctic tern productivity was 0.38 chicks/pr in 2010 and 0.25 chicks/pr in 2011. Target productivity levels are 1 chick / pr.

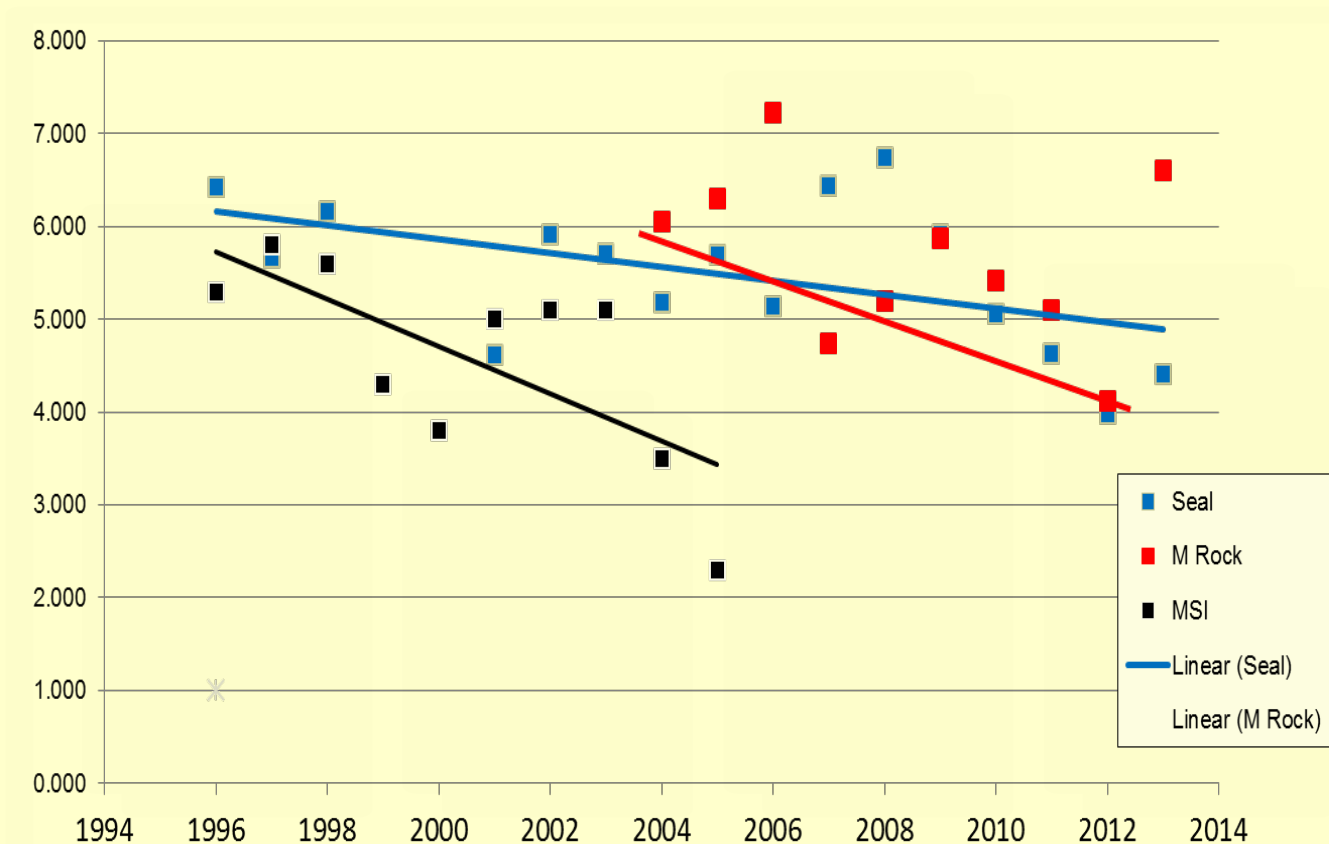
Foraging Effort

Incubation				Chick Rearing			
Species	# trips/ day	Hours / day	Ave flight time(m)	# trips/ day	Hours/ day	Ave flight time(m)	% of day foraging
COTE	5.8	4.8	50.2	7.1	11.1	94.4	57.3
ARTE	8.1	8.3	61.1	10.9	13.9	76.8	62.3

- We used Nanotags to track foraging effort and colony attendance patterns
- Arctic terns made significantly more foraging trips per day than common terns
- Both species made significantly more trips during chick rearing than incubation
- Both species are spending more than 11 hrs per day foraging for themselves and their chicks. They can't simply increase effort to compensate for declining forage fish availability
- Both species foraged at night (2-3 hrs / night), increasing potential collision risk with any structures in offshore environment

Chick Fitness

Linear Growth Rates for Arctic Tern Chicks



- The Linear Growth Rate (average daily weight gain from day 5-15) has been decreasing in recent years, presumably due to lack of suitable forage fish
- Tern colony on MSI completely abandoned in 2006 due to lack of food and extensive predation. Terns did not successfully breed again until 2015
- Arctic terns migrate an average of 66,430 km /year to winter in the Antarctic. Chicks fledging at a lower body weight may have lower survival rates than those in better condition