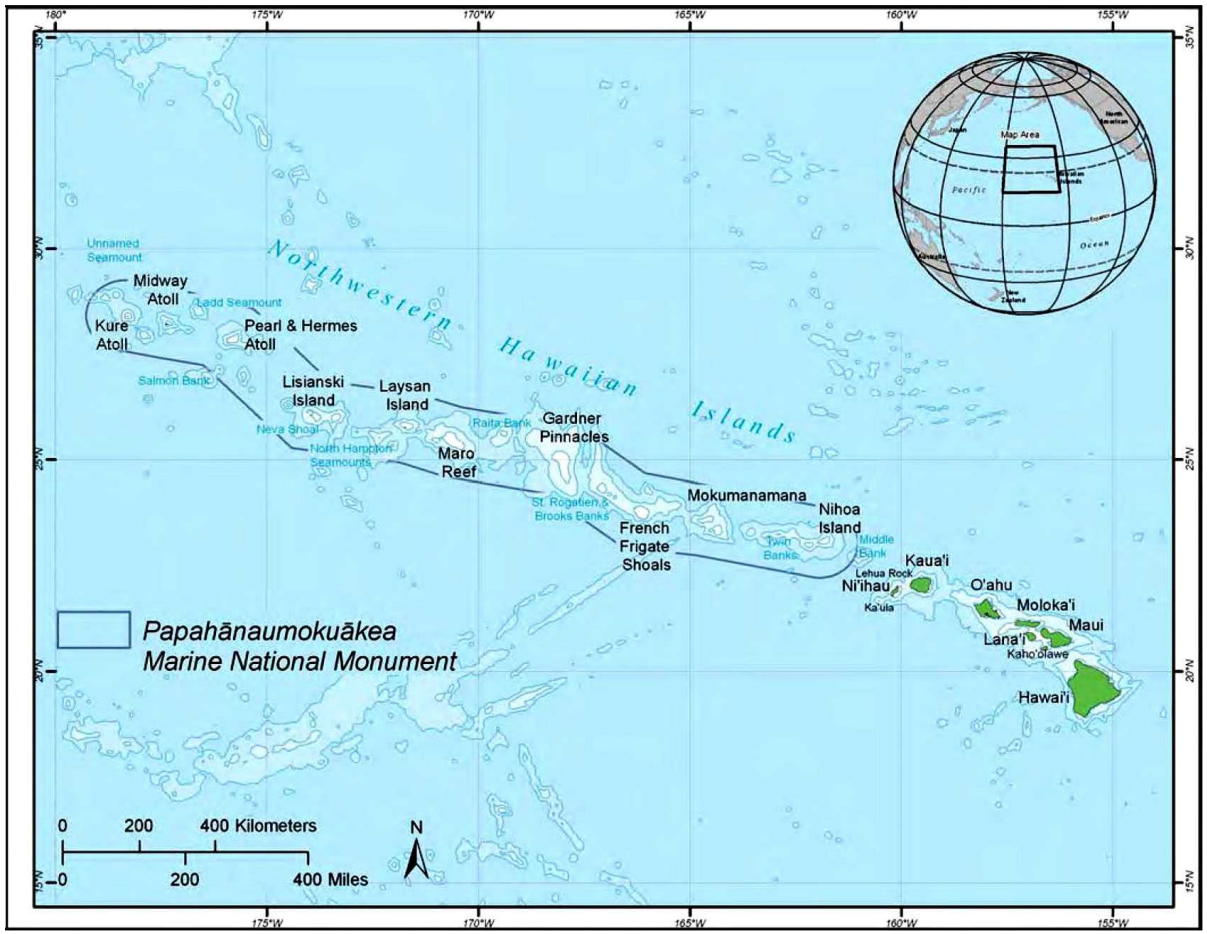
Climate Change and the Living Ocean of French Frigate Shoals

Papahānaumokuākea Marine National Monument (PMNM)

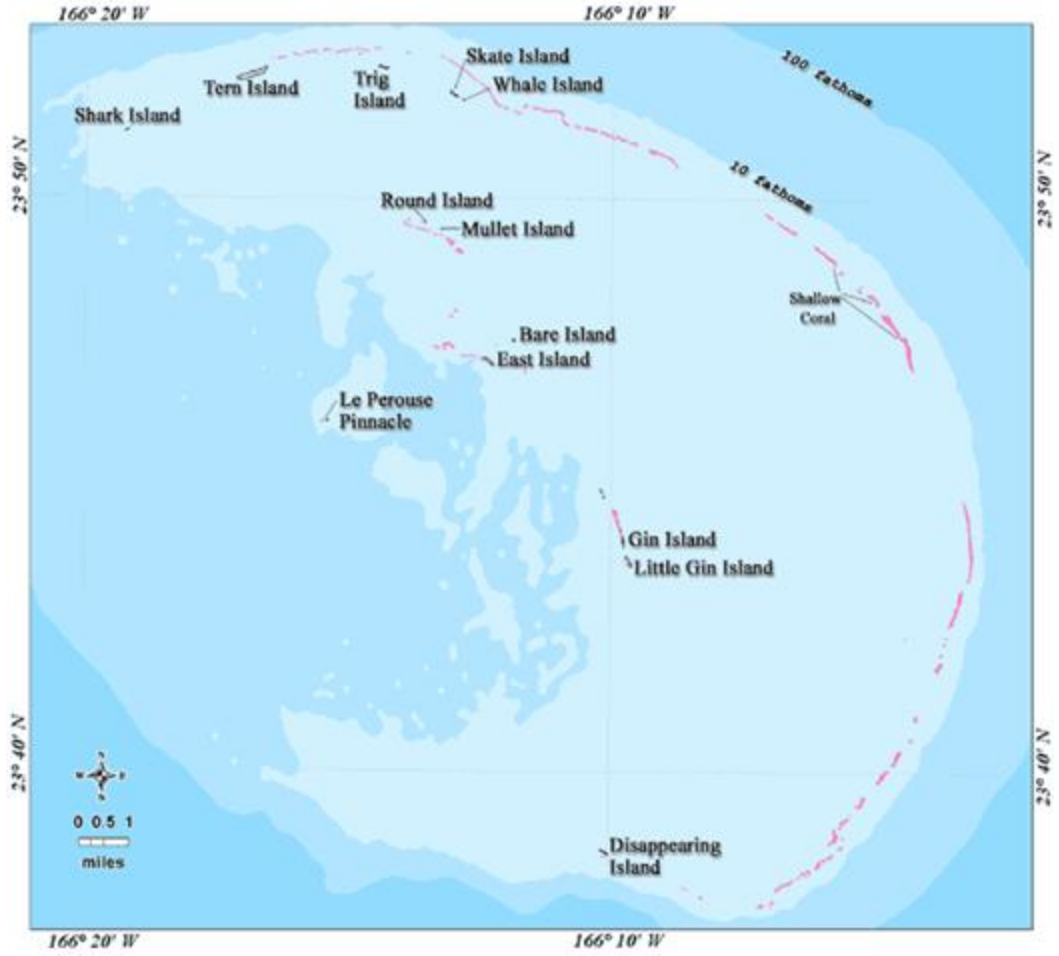
Monument Mission: Provide management to ensure ecological integrity and achieve strong, long-term protection and perpetuation of NWHI ecosystems, Native Hawaiian culture, and heritage resources for current and future generations.

French Frigate Shoals (FFS) is located about half-way along the Hawaiian Island chain and is part of the Hawaiian Island National Wildlife Refuge (NWR), which is in turn part of the PMNM created in 2006.



French Frigate Shoals (Kānemiloha'i)

French Frigate Shoals is the largest atoll in the Hawaiian Island chain. It includes approximately 230,000 acres of coral reef habitat, and about 67 acres of emergent land found in 9-14 sandy islands. FFS is home to 90% of nesting Hawaiian Green Sea Turtles, 18% of endangered Hawaiian monk seals, and 18 species of seabirds.



Biological Monitoring at FFS

Regular seabird monitoring has occurred for the past 30+ years under the control of FWS.

Monitoring includes:

- Mean Incubation Counts
- Reproductive Success
- Lineage Tracking
- Growth Studies
- Special projects (i.e. mapping foraging patterns with the use of geolocator tags, plastics ingestion, artificial habitat affects on chick survival)
- Outer island surveys

Land Loss

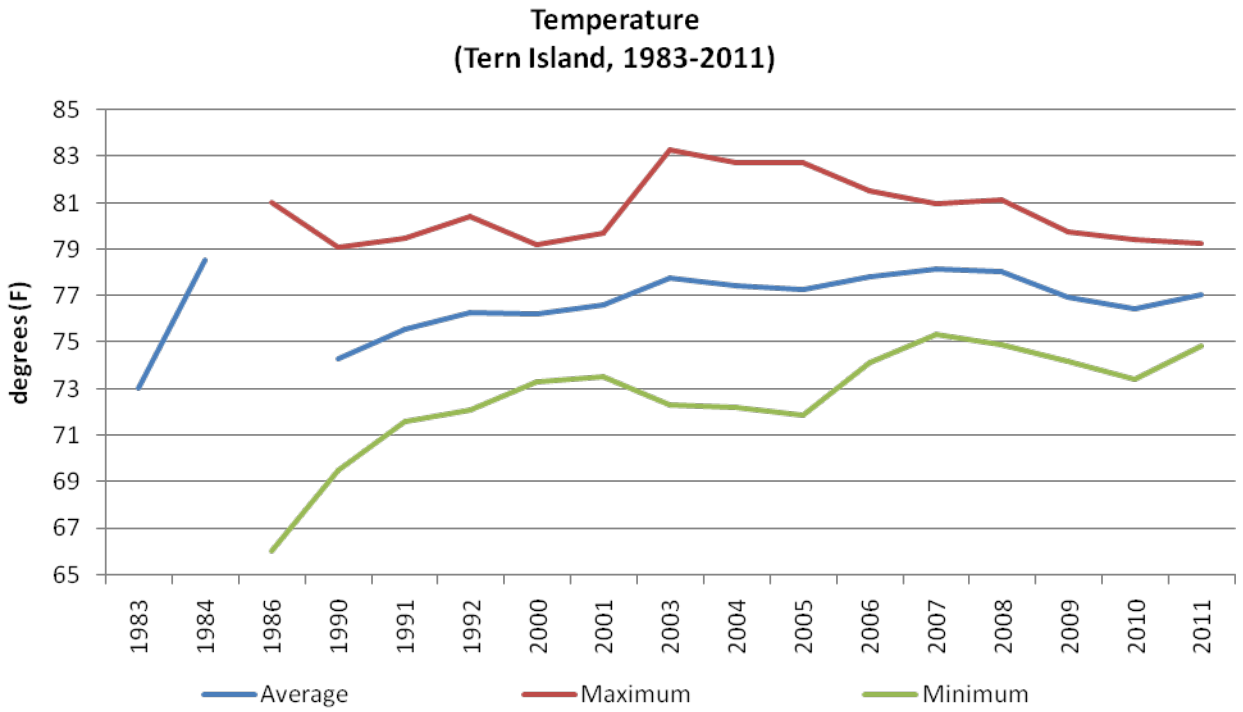
- Tern Island, currently about 28.75 acres in size, has seen small fluctuations in its size from natural deposition and erosion.
- Tern Island represents about 98% of the vegetated habitat between Laysan Island and Nihoa Island, a distance of over 800 miles.
- It provides the most significant seabird nesting and most protected seal pupping habitat in this area.

- Whale and Skate Islands were separate islands which slowly grew together through natural depositional processes.
- The island began to diminish through natural erosion in the late 1980's, was small in the early 1990's, and disappeared altogether in a storm during 1996.

- Continued erosion and sea level rise are cause for concern as islands such as Trig and East stand only a couple feet above water at current times.
- Both East and Trig host significant sub populations of Masked Boobies and Black-Footed Albatross within the atoll as well as providing critical habitat to pupping monk seals.
- East Island alone is the preferred nesting site of over 60% of Hawaiian Green Sea Turtles and its loss would greatly affect an already threatened species.

Temperature

- We have compiled annual and monthly temperature information for January, March, June and December, from 1983-2011.
- Temperature has raised almost 2°F in 30 years, from an average of 75.8°F in the 1980's, to 77.5°F in the late 2000's.
- Temperature plays a significant role in turtle offspring sex ratios. If the mean temperature of sand at nests sites is above a critical point, eggs are predominately female and the reverse for male. This can cause concern if the populations sex-ratio starts to favor one gender over the other.

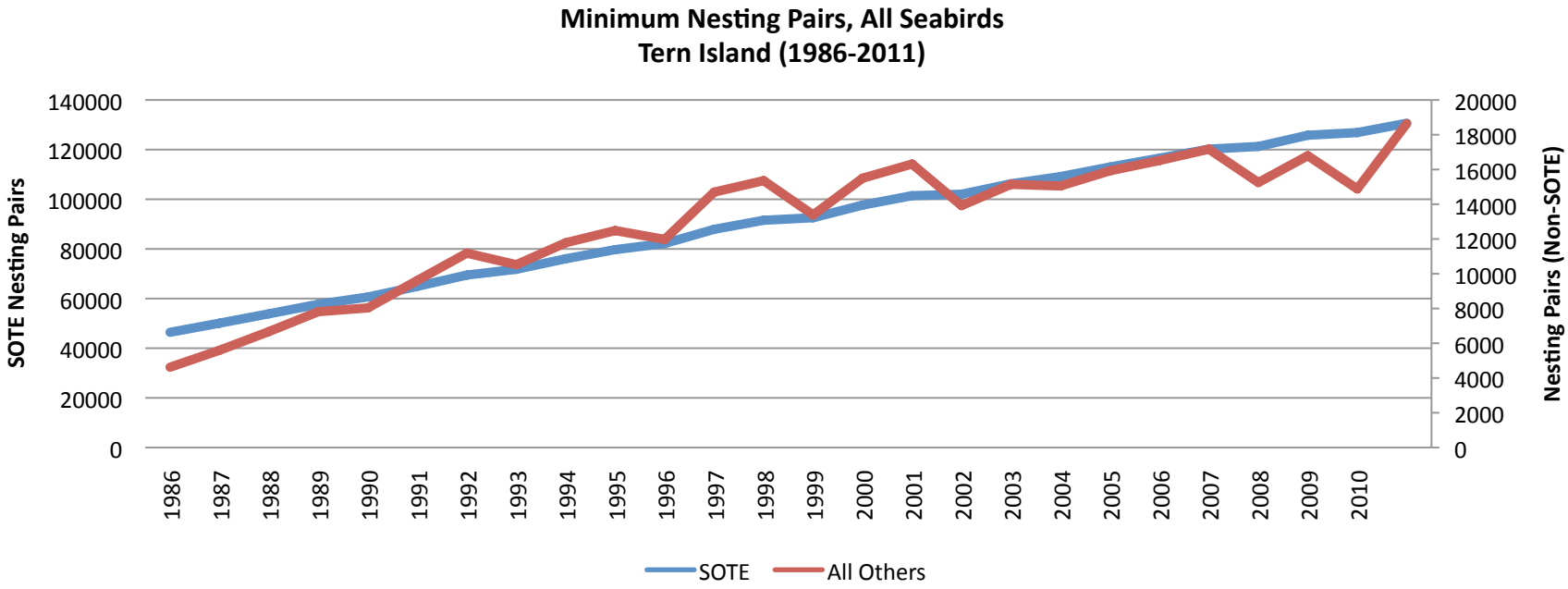


Summary of Weather Patterns

- Changes in weather variables at FFS indicate a strong overall trend toward increasing variability, but less seasonality in climate.
- Variation in spring, summer and fall rainfall have almost doubled over the study period, resulting in greater year-round variability, but less seasonality in rainfall.
- The maximum wind speed recorded during morning weather observations has dropped by an average of 10 knots over the past two decades.
- Current trends are toward decreased seasonality with increased variability, consistent with predictions for tropical areas in warmer global temperatures.
- These changes will be reflected in changes to the ecosystem as a whole, both through potential changes in type, timing, distribution and quantity of primary productivity, but in species' abilities to adapt to changing forage, fresh water availability, and thermoregulatory challenges.
- We expect to see both changes in habitat, and survivorship in species unable to adapt to these climatological changes.

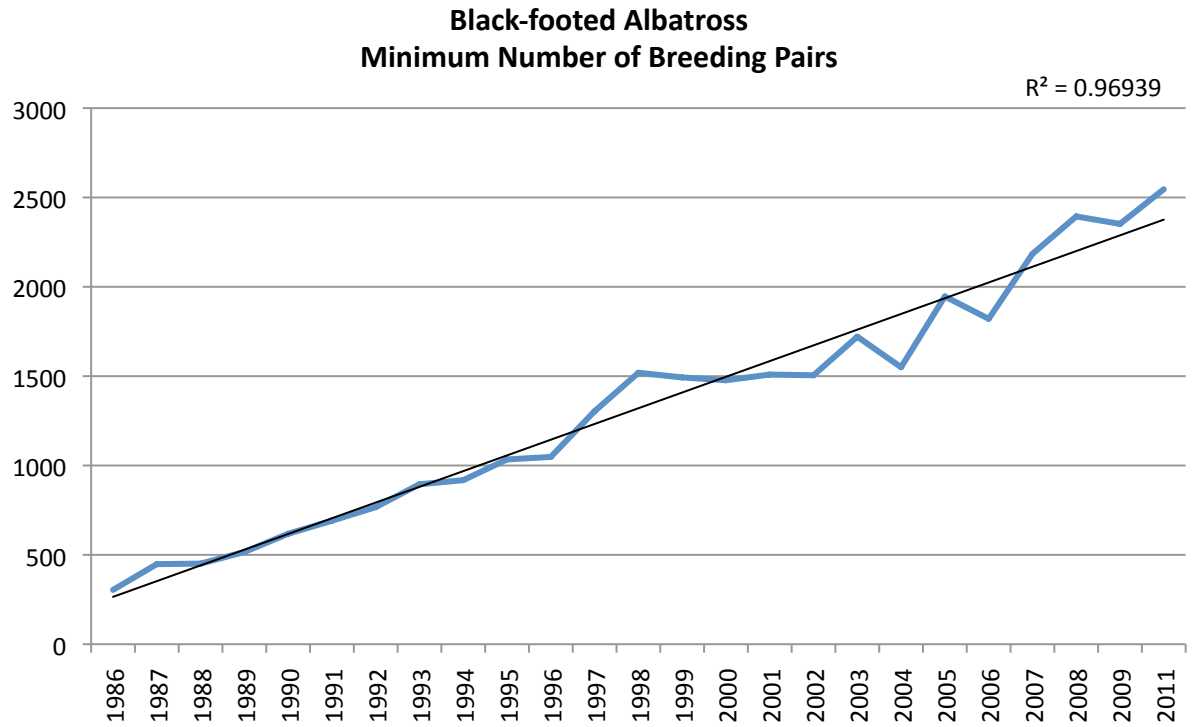
Seabird Population Trend

The seabird population on Tern Island has been increasing since U.S. Coast Guard abandonment in the late 1970's.



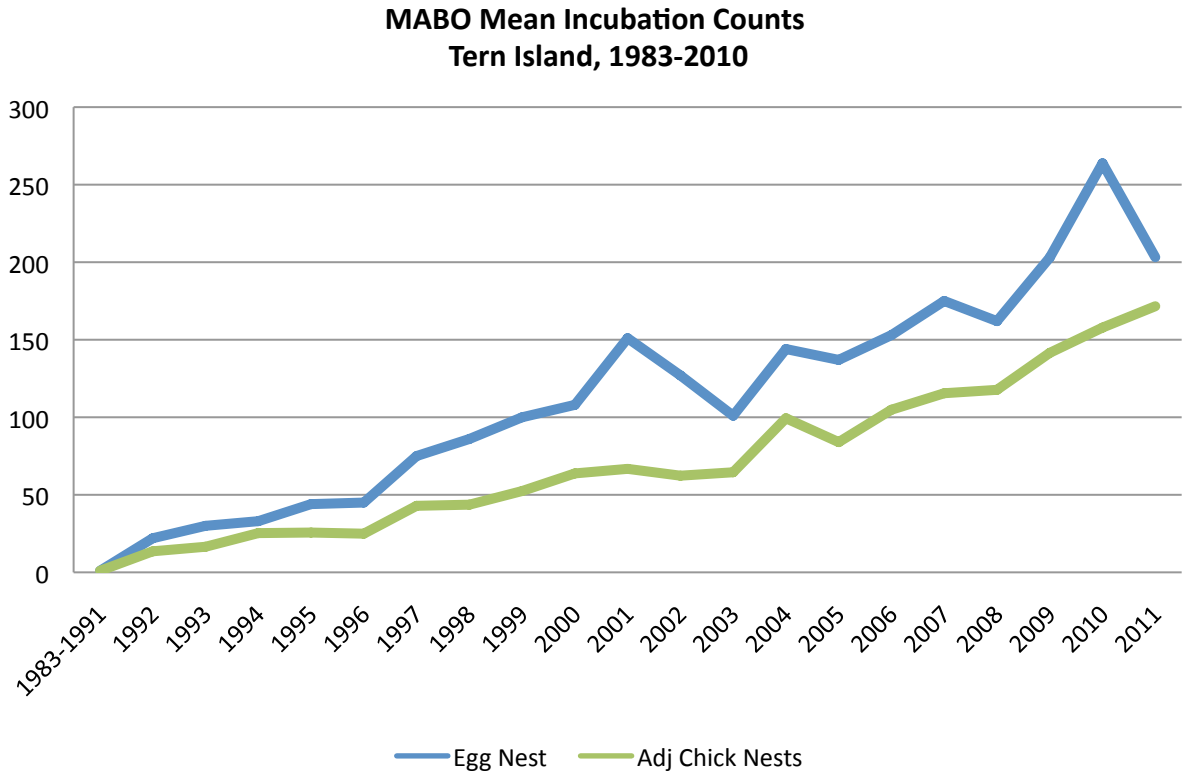
Black-Footed Albatross (BFAL)

- About 4-8% of the world's population of black-footed albatross reside in FFS.
- The minimum number of nesting pairs on Tern Island has increased steadily over the past 25 years, from 304 pairs in 1986, to 2,546 pairs in 2011 .



Masked Booby (MABO)

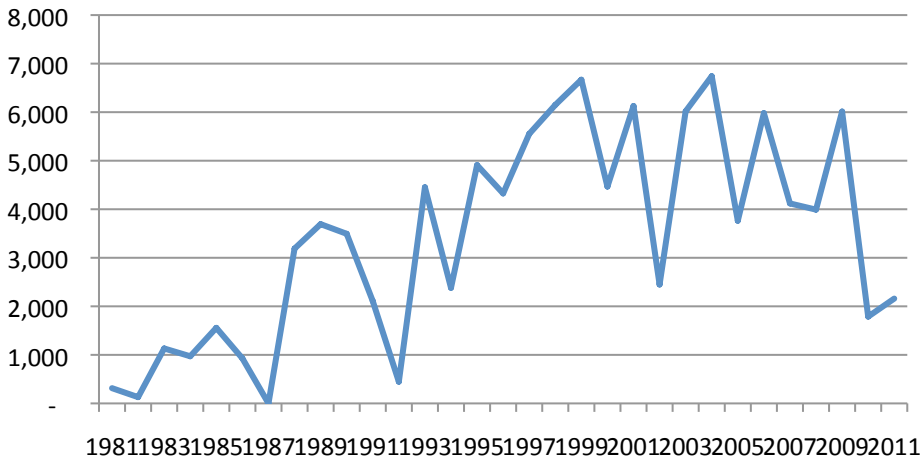
- The breeding MABO population has grown steadily on Tern Island since 1992.
- Number of egg nests, number of chicks, and egg success have all increased significantly from 1992-2011.



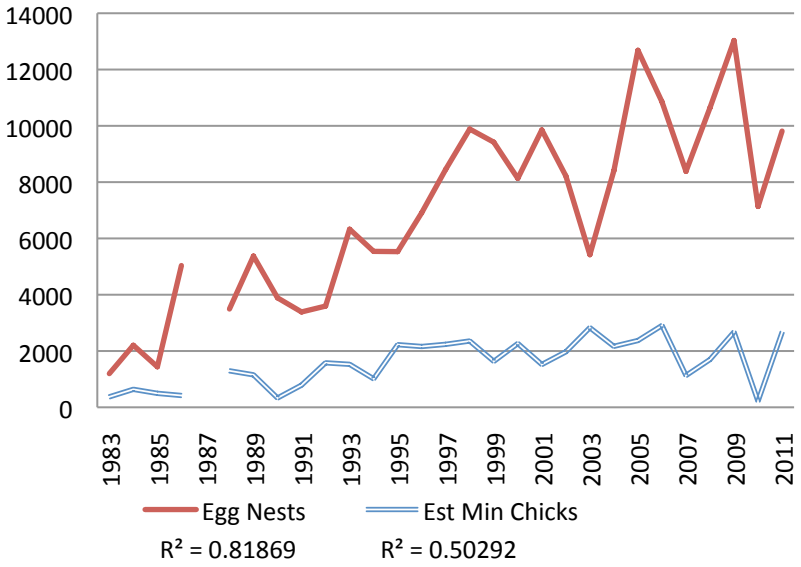
Black Noddy (BLNO) vs. Brown Noddy (BRNO)

- Growth in minimum breeding pair of BLNO and BRNO are inversely related.
- Trend in 7 year average for BLNO minimum breeding pairs suggests that the reduction in BLNO reproductive effort is not caused by reduced egg or chick success, and may therefore be due to higher rates of adult mortality or reduced fecundity (e.g., through reduced forage, increased interspecies competition, etc), although habitat limitation is not eliminated as a possible contributing factor.

Annual Total BLNO MIC Egg Nests

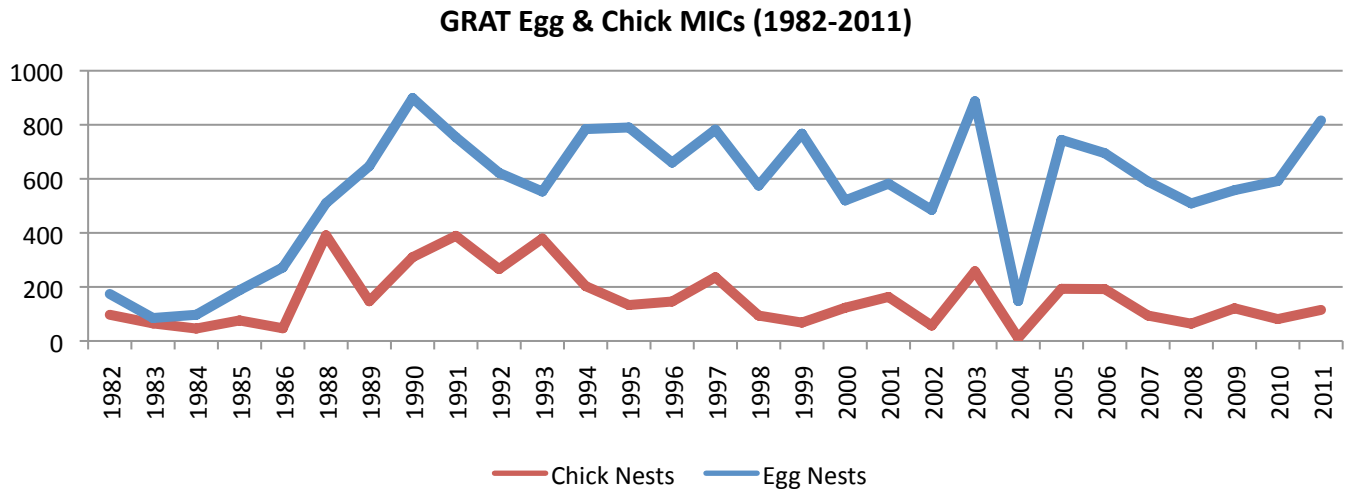


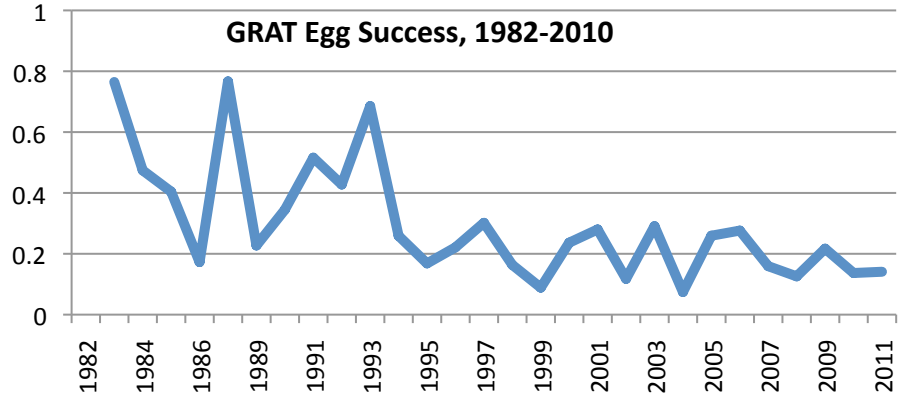
BRNO Reproductive Effort on Tern Island, FFS



Gray-Backed Tern (GRAT)

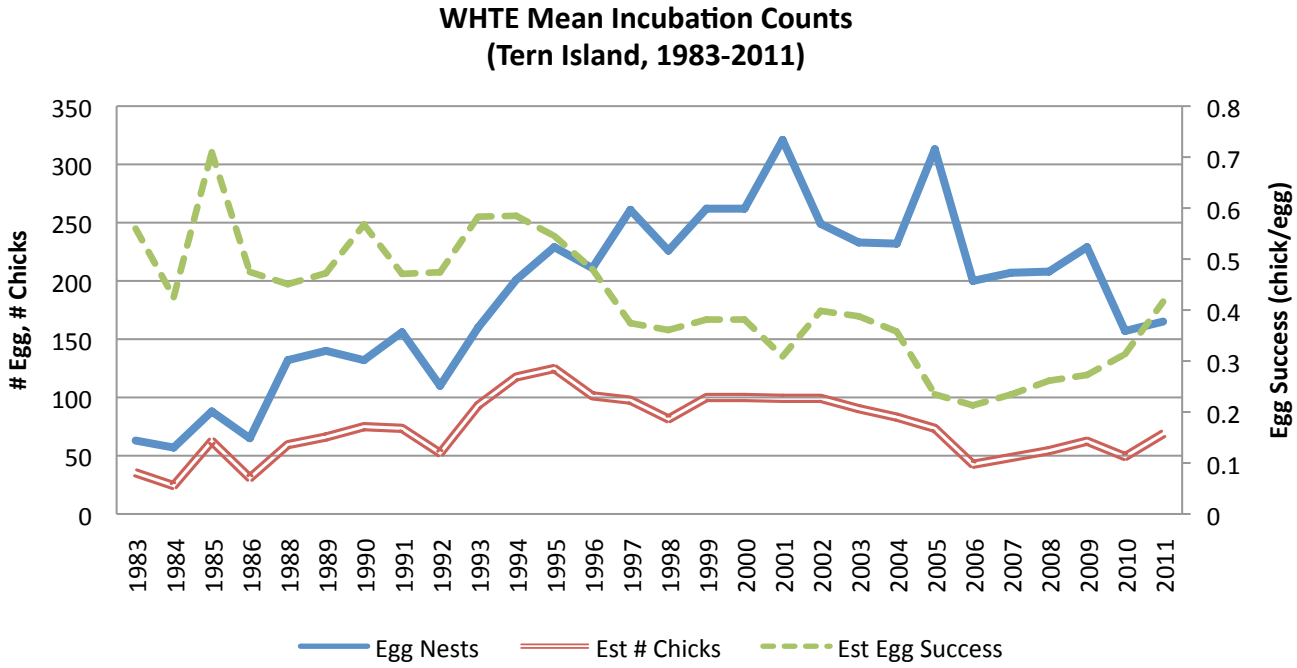
- GRATs feed almost entirely on fish (92%, 4% squid, and 3% crustaceans) and feed inshore during the reproductive period.
- The GRAT population may therefore be impacted by declining prey abundance.





White Tern (WHTE)

- WHTE reproductive effort (# egg nests) and egg success (# chicks/# egg) show startlingly different patterns. Reproductive effort increased between 1983 and 2001.
- WHTE reproductive effort peaked in 2001, however, with a steady increase in reproductive effort before 2001,and a fairly consistent decline following 2001.
- Natural habitat is not a limiting factor for Tern Island WHTEs; likewise, the only natural predator on Tern Island, Great Frigatebirds, have exhibited a simple increase, unlike the WHTE pattern.
- We therefore conclude that other factors – forage quality or quantity, disease, weather patterns are having greater influence on the Tern Island population.



Diet, Forage Distance, and Population trends of Tern Island Seabirds

•We would expect that forage limitations would become important only as populations near carrying capacity as determined by forage.

•Although quantitative analyses of forage is beyond the scope of the current study, it appears that those species that are heavily dependent on fish (>80%) are the most susceptible to decline under current conditions.

•Most of the declining or recently declining species are near-shore fish-dependent species, further limiting their adaptability.

•Generalist species, and those more dependent on squid appear to be fairing better.

•A shift in surface fish availability, particularly if that is coupled with a decrease in benthic prey, will have a profound effect on all elements of the ecosystem.

Forage	BOPE	BFAL	BLNO	BRNO	BUPE	CHSH	GRAT
% Fish	47%	0	92%	66%	71%	50%	92%
% Squid	21%	32	7%	33%	22%	48%	4%
Distance	mid	far	near	near	mid	mid	near
Population	Stable	Incr	Decr	Incr	stable	stable	Decr
Forage	LAAL	MABO	RFBO	RTTR	SOTE	TRSP	WHTE
% Fish	9%	90%	64%	82%	46.50%	23%	88%
% Squid	65%	10%	36%	18%	53.50%	29%	12%
Distance	far	mid	mid	mid	mid	unk	near
Population	Incr	Incr	Incr	Decr	Incr	Incr	Decr

Climate Change and Predator-Prey Trends

- Climate change is also expected to result in changes to seabird foraging patterns, through increased distance of oceanic fronts which are associated with both Laysan and Black-footed albatross foraging during the reproductive season, as well as local changes in near shore waters.
- Concurrent changes in sea surface temperature, oceanic fronts, seabird trends for fish-dependent versus generalist species, the decline in Hawaiian monk seal, decline in lobster species in the area, and known shifts in weather and climate all support a conclusion of substantial changes in prey species in this area.
- Generalist species and those with greater dependence on squid have faired better than seabirds species with a high dependence on fish.
- Shifts in sea surface temperature and currents may be disfavoring fishes relative to non-fish species such as squid and octopus.
- Expanded effort in identifying trends in prey species and foraging patterns, particularly during the reproductive season, will help us to understand how birds are adapting to this change, while health and reproductive studies will help us to understand its impact to the population.

Future Outlook

- Given the trends and current data how would you approach managing and quantifying the affects of climate change in French Frigate Shoals?