Extreme response of seabirds to extreme climate events in the NE Pacific

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Distribution of 60,000 murre carcasses on beaches May 2015 – Apr 2016

Dead Murres Obs.
- 1 - 200
- 201 - 800
- 801 - 2500
- 2501 - 5000
- 5001 - 16814

Distribution of murres at sea

Summer (May-Oct)

Kilometers
0 500 1,000 2,000

[Map showing the distribution of murre carcasses on beaches and at sea]
Murres died of starvation

Factors contributing to starvation:
- Breeding stress
- Post-breeding molt
- Winter storms

Factors that were NOT a major cause of mortality, although some affected a small number of birds:
- Domoic acid
- Saxitoxin
- Salmonella
- Infectious disease
- Parasites
- Oil pollution

Data: USGS (Bodenstein, Piatt), Piatt et al. 1997  
Piatt et al. in prep
Supporting evidence of food scarcity: Unprecedented breeding failures at Common Murre colonies from California to Alaska.
Worst Years:
Lowest 15% of breeding success observations (N=423)

Almost half (44%) of all worst years occurred in association with 2014-2016 heatwave
1997-1998 ENSO
Other mortality events of marine bird and mammal species in the GOA and CCS during the 2014-2016 heatwave

- Cassins Auklet 2014-2015 (100K)
- Common Murre 2015-2016
- Rhinoceros Auklet 2016
- Tufted Puffin 2016
- Guadalupe Fur Seal 2014-2015
- California Sea Lion 2014-2016
- Humpback and Fin whales 2015-2016
Common Murres: Masters of their domain

So why did this die-off happen?
Event Attribution: Decomposition of SST signal for the Gulf of Alaska and the California Current System

Sea Surface Temperature (SST) record from January 1870 to May 2017 from the reanalysis dataset HadISST1

Analysis: García-Reyes, Sydeman, Piatt, in prep.
1) Largest sustained SST anomaly during past 147 years
2) Most rapid and extreme rise from low to high SST
3) Exceeds 1976 regime shift for magnitude and rate of change (but not duration)
Drivers of SST Variability in Phase

- GOA SST anomalies
- Remove PDO: 28% / 35%
- Remove ENSO: 12% / 22%
Effect of the heatwave on forage fish typically consumed by murres

% change in forage biomass in 2015 from average biomass in 2007-2014

- Capelin
- Sand lance
- Herring AK
- Pollock
- Cod
- Herring CA
- Sardine
- Anchovy
- HE-Sitka
- Hake
- Rockfish
- Sand Dab
- Squid
What could cause wide-spread loss of access to forage fish?

1) Commercial fishing (**not likely**)
2) Redistribution of fish out of reach of birds (**possibly, but murres can go everywhere**)
3) Reduced recruitment (**likely some species, some areas**)
4) Increased metabolic rate of predatory fish (**affects all species, all areas**)
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\[ x10 = +2 \text{ deg C} \]

**Ectotherm Effect?**

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**Diagram:**

(a) Climate-trophic control

- Y-axis: Cod-prey correlation (r)
- X-axis: Temperature index (PC1 score)

(b) Community state-trophic control

- Y-axis: Community state (NMDS axis 1 score)
- X-axis: Temperature index (PC1 score)

- Red circles indicate years: 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98

- Legend:
  - More shrimp & capelin
  - More groundfish
What did it mean when half a million of the dominant fish-eating seabirds of the North Pacific died *en masse* from starvation?

D. Irons
Extreme ocean warming precipitated “Ectotherm Effect” resulting in a major perturbation to food webs across several contiguous Large Marine Ecosystems.

Prediction: ripple and hangover effects of this perturbation on less visible members* of these LMEs in following years…

* e.g., Pacific Cod - see Steven Barbeaux
Thanks for hanging out with me!
At home on land too!
Stay on the deck of the Ripley by my side this clear and cold morning. See how swiftly sends our gallant bark, as she cuts her way through the foaming billows, now inclining to the right and again to the left. Far in the east, dark banks of low clouds indicate foul weather to the wary mariner, who watches the approach of a northern storm with anxiety. Suddenly the wind changes; but for this he has prepared; the topsails are snugged to their yards, and the rest are securely reefed. A thick fog obscures all around us. The waters, suddenly checked in their former course, furiously war against those which now strike them in front. The uproar increases, the bark is tossed on every side; now a sweeping wave rushes against the bows, the vessel quivers, while down along her deck violently pour the waters, rolling from side to side, seeking for a place by which they may escape. At this moment all about you are in dismay save the Guillemots. The sea is covered with these intrepid navigators of the deep. Over each tumultuous billow they swim unconcerned on the very spray at the bow of the vessel, and plunging as if with pleasure, up they come next moment at the rudder. Others fly around in large circles, while thousands contend with the breeze, moving directly against it in long lines, towards regions unknown to all, save themselves and some other species of sea birds.
THE END