Reproductive responses of planktivorous and piscivorous seabirds to climate variability in the northern Sea of Okhotsk

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Inter-annual oceanographic change

Seabird reproductive performance

Causal links between reproduction and climate variability on small and large geographic scales

Change in diet composition: over time and in relation to climate variability
Bering Sea (1960s-1990s)

- decline in populations of piscivorous seabirds
  Springer 1992
  Hunt & Byrd 2000

- increase in populations of planktivorous seabirds
  Piatt et al. 1990
  Konyoukhov 1991
Sea surface temperature in the Bering Sea

YEAR
SST ANOMALY (°C)

planktivorous increased
piscivorous declined

WARM phase
COLD phase

Study area:
Talan Island
1987-2001
Study hypothesis: environmental change causes contrasting trends in reproductive performance of planktivorous and piscivorous alcids.
Reproductive success

SST (July 1 - August 30) °C

Tufted puffin
Horned puffin
Parakeet auklet
Crested auklet

Year

long-term SST = 9.3 °C
Sea-Surface Temperature

"WARM" PHASE

"COLD" PHASE

Year

SST (July 1 - August 30°C)
Dates of permanent ice disappearance

- **“WARM” PHASE**
- **“COLD” PHASE**
Reproductive success (%)

OCEANOGRAPHIC REGIME

Kitaysky & Golubova 2000
Talan I.
Sea of Okhotsk 1987-1994

- Planktivorous auklets
- Piscivorous puffins
Distribution of adult euphausiids *Thysanoessa rashii* (major prey of planktivorous auklets)
Distribution of *Acartia* and calanoid copepods (major prey of small “forage” fish)

**“COLD” regime**

**“WARM” regime**
Talan I.
1987-2001

Reproductive success
(deviation from long-term mean)

Sea-surface temperature ANOMALY (°C)

planktivorous:
- Crested auklets
- Black-legged kittiwakes

piscivorous:
- Tufted puffins

- Talan I.
- 1987-2001
- Reproductive success (deviation from long-term mean)
- Sea-surface temperature ANOMALY (°C)
Conclusion:
Environmental change affects trophic level linkages in marine ecosystems

- Alternations in distribution of zooplankton are driven by local inter-annual oceanographic change

- Reproductive performance of planktivorous and piscivorous seabirds reflects these changes
Is reproduction of birds in the northern Sea of Okhotsk related to climate variability on a large geographic scale?
## Talan SST vs composite indices of climate in the North Pacific
### 1986-2003

<table>
<thead>
<tr>
<th></th>
<th>PDO</th>
<th>NPI</th>
<th>AO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Talan I. SST</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>August</em></td>
<td>$r=-0.54$</td>
<td>$r=+0.78$</td>
<td>$r=+0.53$</td>
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<tr>
<td></td>
<td>$P&lt;0.04$</td>
<td>$P&lt;0.001$</td>
<td>$P&lt;0.04$</td>
</tr>
</tbody>
</table>
Talan I.  
1987-2003
Talan I.
1987-2003

![Graph showing the relationship between AO index anomaly and reproductive success anomaly for Crested auklet, Horned puffin, and Tufted puffin.](image)
Talan I.
1987-2003

Graph showing the relationship between AO index anomaly and reproductive success anomaly. The graph includes two lines:
- Red line: Crested auklet
- Blue line: Horned puffin and Tufted puffin
Conclusion:
Environmental change affects trophic level linkages in marine ecosystems

- Alternations in reproduction of piscivorous and planktivorous seabirds in the northern Sea of Okhotsk are driven by inter-annual oceanographic change on large geographic scale
Are DIETs of birds in the northern Sea of Okhotsk related to changes in climate phenomena on a large geographic scale?
### Diet composition of puffin chicks on Talan I. 1987-2003

<table>
<thead>
<tr>
<th></th>
<th>Fish</th>
<th>Invertebrates</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Horned Puffin</strong></td>
<td>29 spp</td>
<td>6 spp</td>
</tr>
<tr>
<td>N=6 years</td>
<td>99% biomass</td>
<td>1% biomass</td>
</tr>
<tr>
<td><strong>Tufted Puffin</strong></td>
<td>37 spp</td>
<td>7 spp</td>
</tr>
<tr>
<td>N=9 years</td>
<td>98% biomass</td>
<td>2% biomass</td>
</tr>
</tbody>
</table>
Change in diet composition, SANDLANCE 1987-2003

YEAR % BIOMASS, wet
0 10 20 30 40 50 60 70 80 90 100

Horned puffin
Tufted puffin
Change in diet composition, Tufted puffin, 1987-2003

HERRING

CAPELIN
Change in diet composition, Tufted puffin, 1987-2003

Pacific lamprey

YEAR

%BIOMASS, wet

Talan I.
1987-2003

Change in diet composition, Tufted puffin, 1987-2003

YEAR

%BIOMASS, wet


Age 1+ Saffron cod
Age 0+ Walleye Pollock
Are DIETs of birds in the northern Sea of Okhotsk related to climate variability on a large geographic scale?
Diet (% biomass) vs composite indices of climate in the North Pacific 1986-2003

<table>
<thead>
<tr>
<th></th>
<th>PDO</th>
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<th>NPI</th>
<th></th>
<th>AO</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>annual mean</td>
<td>Jan-April mean</td>
<td>annual mean</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horned Puffin</td>
<td>r=+0.91</td>
<td>r=-0.74</td>
<td>r=-0.95</td>
<td>P&lt;0.011 gadids</td>
<td></td>
<td>P=0.090 gadids</td>
</tr>
<tr>
<td>N=6</td>
<td>P&lt;0.011</td>
<td></td>
<td>P&lt;0.01</td>
<td>pollock</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>r=+0.66</td>
<td></td>
<td>r=-0.60</td>
<td>P=0.055 Saffron</td>
<td></td>
<td>Saffron cod</td>
</tr>
<tr>
<td>Tufted Puffin</td>
<td></td>
<td>r=0.60</td>
<td>P=0.088</td>
<td>cod</td>
<td></td>
<td></td>
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<tr>
<td>N=9</td>
<td></td>
<td></td>
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</tbody>
</table>
Diet (% biomass) vs reproductive performance of puffins on Talan I. 1986-2003

<table>
<thead>
<tr>
<th></th>
<th>Pollock</th>
<th>Flatfish</th>
<th>Poachers</th>
<th>Squid</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Repr. success</strong></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td><em>Horned Puffin</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>N=6 years</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>r</em></td>
<td>-0.80</td>
<td>-0.89</td>
<td>-0.97</td>
<td>-0.94</td>
</tr>
<tr>
<td><em>P</em></td>
<td>0.057</td>
<td>&lt;0.02</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
Summary

1. Local oceanographic conditions in the northern Sea of Okhotsk are driven by large-scale oceanographic patterns

2. Availability of forage fish and consequently seabird reproduction are determined by these patterns

3. The same oceanographic event has opposite consequences for planktivorous and piscivorous birds

4. Whether these relationships are specific to the Sea of Okhotsk or apply to other arctic regions remains to be seen
• Thanks to:
  - A. Andreev, J.F. Piatt, and all the Russian and American colleagues and students who participate in this ongoing project

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  - EVOS
  - NPRB
  - Institute of Arctic Biology, UAF