Shifting Prey in a Melting Ocean:
Seabirds Reveal Annual and Seasonal Changes
in Arctic Nearshore Fish

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Can one use a seabird to monitor temporal changes in prey (fish) type and abundance?
The Arctic’s cryopelagic ecosystem
Studies conducted annually on Cooper Island 1975-2012
Creation of nest sites for
400 Black Guillemots in 1980s
Access to all nest contents during breeding season
Black Guillemot

*Cepphus grylle*

- Cavity-nesting diving seabird
- High plasticity in nest selection
- Semi-colonial
- Forages in nearshore while breeding
Why guillemots are good samplers of nearshore fish
Piscivorous while provisioning young
Provisioning parents carry prey cross-wise in bill
Well-defined foraging area when provisioning nestlings
Raise two chicks that have a ten-fold increase in weight over 35 days.
Linear growth phase, and asymptotic and fledge weights provides a way of comparing temporal variation in prey availability.
Why Cooper Island is a good place to study Black Guillemots

- From approximately 20 July to 5 September nearly 100 thousand fish returned to island
- 1400 hours of continuous sampling
Why Black Guillemots are good arctic samplers
Black Guillemot Breeding in the Alaskan Arctic

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<thead>
<tr>
<th></th>
<th>June</th>
<th>July</th>
<th>August</th>
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<tbody>
<tr>
<td>Pre-egg</td>
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<td>Egg-laying</td>
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<td>Incubation</td>
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<td>Nestlings and chick provisioning</td>
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*Retreat of ice*
Direct observations and images from SLR with telephoto lens
Motion-sensitive cameras at nest sites
Considerations when using guillemots as a fish sampler

- Seeks out prey closest to the colony and most easily obtained increasing variation in sampling area and depth
- Selects prey based on appropriate size and highest energy content
- Individual preferences of provisioning parents can bias observations
- Lag time in responding to changes in prey
Research on Cooper Island conducted from 1975-2012
Decadal shift in prey

1975-2002
Arctic Cod primary prey fed to nestlings

2003-2012
(with exception of 2006)
Reduction and disappearance of Arctic Cod
Sculpin become primary prey
AVHRR*-derived SST

*Advanced Very High Resolution Radiometer
Pathfinder AVHRR data (1981-2005) and operational AVHRR data (2006-2012), provided by NOAA's National Climate Data Center (NCDC).
Distance to nearest ice
Regime shifts are defined as rapid reorganizations of ecosystems from one relatively stable state to another. In the marine environment, regimes may last for several decades and shifts often appear to be associated with changes in the climate system. In the North Pacific, climate regimes are typically described using the concept of Pacific Decadal Oscillation. Regime shifts were also found in many other variables as demonstrated in the Data section of this website (select a variable and then click "Recent trends").

There are a number of methods designed for a detection of regime shifts in both the individual time series and entire systems (Rodionov 2005a). The overwhelming majority of these methods, however, experience deterioration in their performance toward the ends of time series. Rodionov (2004) developed a new method based on a sequential t-test that can signal a possibility of a regime shift in real time. Rodionov et al. (2004) and Rodionov and Overland (2005) discuss an application of the method to the Bering Sea ecosystem. The code for the method is written in Visual Basic for Application (Excel). This program can be downloaded by clicking on one of the buttons below. The help file provides information on how to install and run the program.

The program can detect shifts in both the mean level of fluctuations and the variance. The algorithm for the variance is similar to that for the mean, but based on a sequential F-test (Rodionov 2005b). Send your comments/suggestions/bug reports to Sergei Rodionov.
Four two-week periods examined

• Late July – Hatching and early growth

• Early August – Early growth and some hatching

• Late August – Final growth and maintenance

• Early September - Fledging
Late July – hatching and early growth

**SST**

Mean value for regime

**Distance to ice**

**Year**

<table>
<thead>
<tr>
<th>SST - Degrees C</th>
<th>Distance to 3/10 ice</th>
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<tr>
<td>1980</td>
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<td>1990</td>
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<td>2000</td>
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<td>2010</td>
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**1980**

**1996**

**2012**

Early August – Rapid growth

**SST**

Mean value for regime

**Distance to ice**

1980 - [Map Image]

1996 - [Map Image]

2012 - [Map Image]
Late August - maintenance

**SST**

Mean value for regime

**Distance to ice**

- 1980
- 1996
- 2012
September

Mean value for regime

1980

1996

2012
Late August Ice
Late August SST

Arctic Cod

Sculpin
Daily SST in Cod and Sculpin Years

![Graph showing daily SST for Arctic Cod and Sculpin with dates from 07/15 to 09/16]
Daily Ice Concentration in Cod and Sculpin Years

Prey

- **Arctic Cod**
- **Sculpin**
SST, Percent Ice Cover and Chick Deaths- 2012

Nestling deaths
The Prey Shift in the nearshore Beaufort Sea

Adult Arctic Cod → First-Year Arctic Cod → Sculpin

Mid-season transitions result in the greatest decrease in measures of breeding quality
Length (age class) of Arctic Cod provided to guillemot nestlings in two “cod” years

2006

2007

Sculpin

Arctic Cod
Using temperature/depth recorders to examine diving behavior
Daily variation in dive statistics in relation to prey and oceanography
Examining individual dive bouts to determine prey abundance and location
Global SST Anomaly – August 2011

Sea Surface Temperature Anomaly (°C), Base Period 1971–2000
Week of 10 AUG 2011
Conclusions

• Guillemots can be a true “canary in the coal mine”

• They have provided data on trophic changes in a melting Arctic and now can do the same for a melted Arctic
What does the future hold?

• Nearshore prey should become more diverse as subarctic species move north
• We can monitor individual variation in the ability of an upper trophic level predator ability to adapt to changing environment
Another prey shift is likely – probably to a subarctic fish moving into the Arctic.
Thanks for support and encouragement

- Friends of Cooper Island
- SOAR
- Residents of Barrow
- North Slope Borough Wildlife Mgmt.

- North Slope Borough SAR
- Barrow Arctic Science Consortium
- Many field assistants and volunteers