# Aggregation Hotspots

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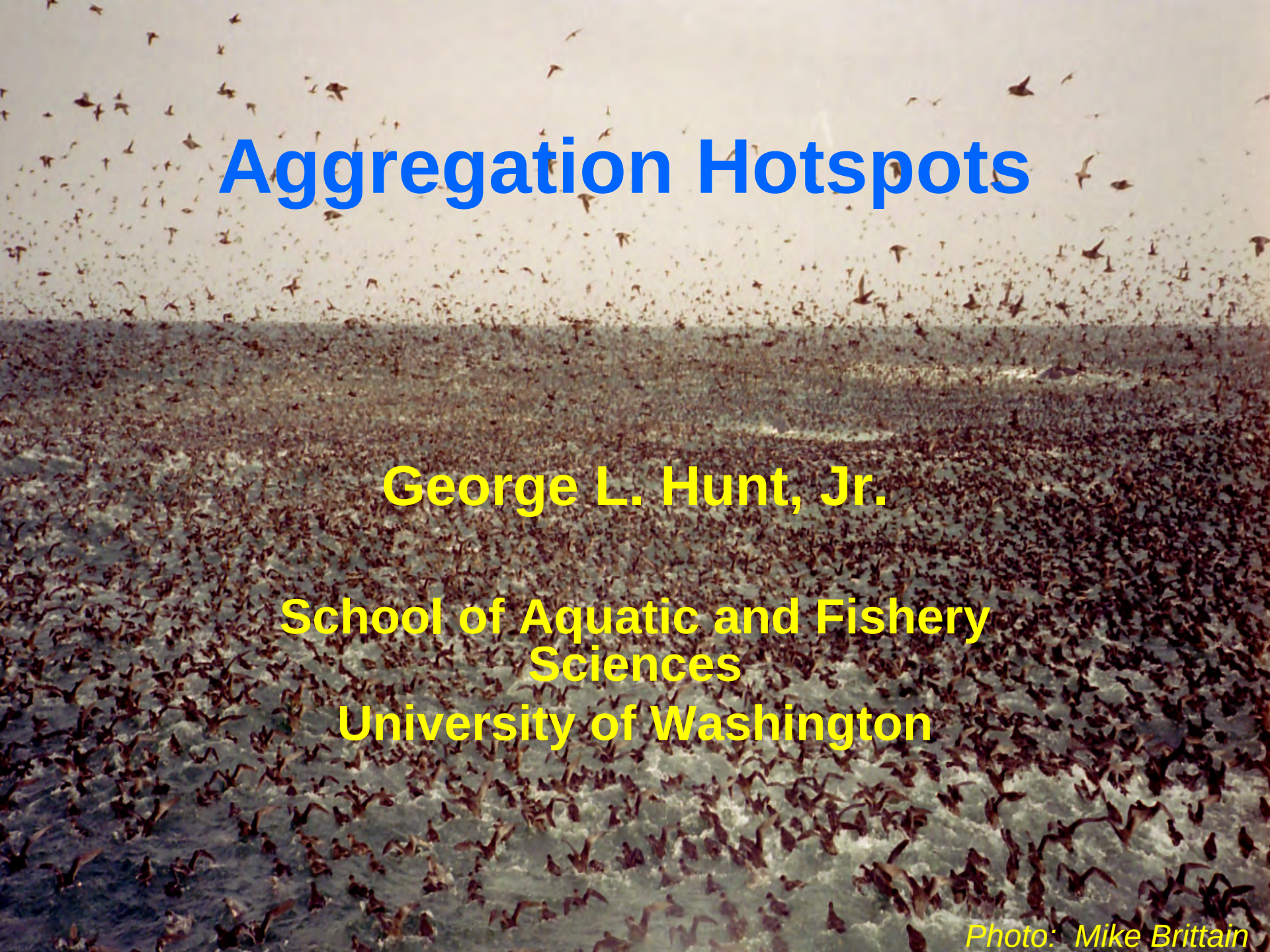


*Photo: Mike Brittain*

# What is a Hotspot?

- Original focus- **Regions of exceptional terrestrial biodiversity**
- Later- Regions of high marine biodiversity
  - Focus on Coral Reefs
  - Equatorial Regions with many species of large predators
- High Latitude Seas- Low biodiversity, but high biomass or abundance
  - Possibly major portions of a species' population in a small area, **Aggregation Hotspots**

# Aggregation Hotspots

- Predictable in Time and Space
- Places with high rates of trophic transfer- foraging areas
  - should we include resting or mating areas? YES
- “Significant proportion” of local or world population
  - What is “Significant”?
  - If destroyed, what would be considered a significant impact at the population level?
- **Places of major conservation Importance**

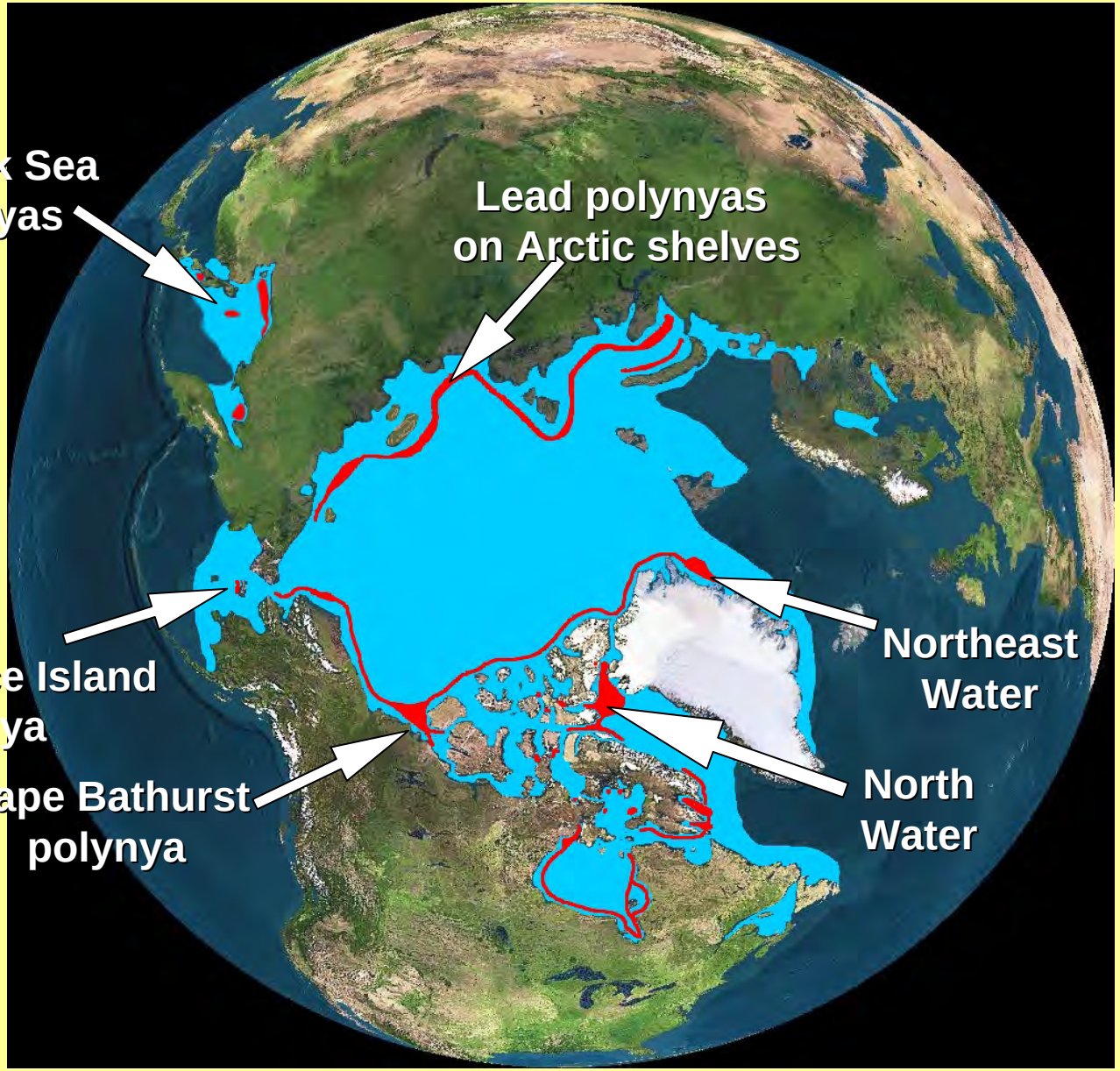
# Hotspots for Trophic Transfer

- **Two major classes of mechanisms**
  - Heightened Productivity
  - Prey behavior working against physical gradients
- **Many different spatial scales**
  - Whole sub-arctic compared to sub-tropical Pacific Ocean- not very informative
  - Mesoscale Regions of heightened productivity
  - Oceanic frontal systems
  - Tidal fronts and rips
  - Appropriate spatial scale depends on organism

# Productivity-driven Hotspots

- **North Water Polynya**
  - Sensible heat polynya
  - Opens early, early bloom, large zoops
  - Supports several million dovekies

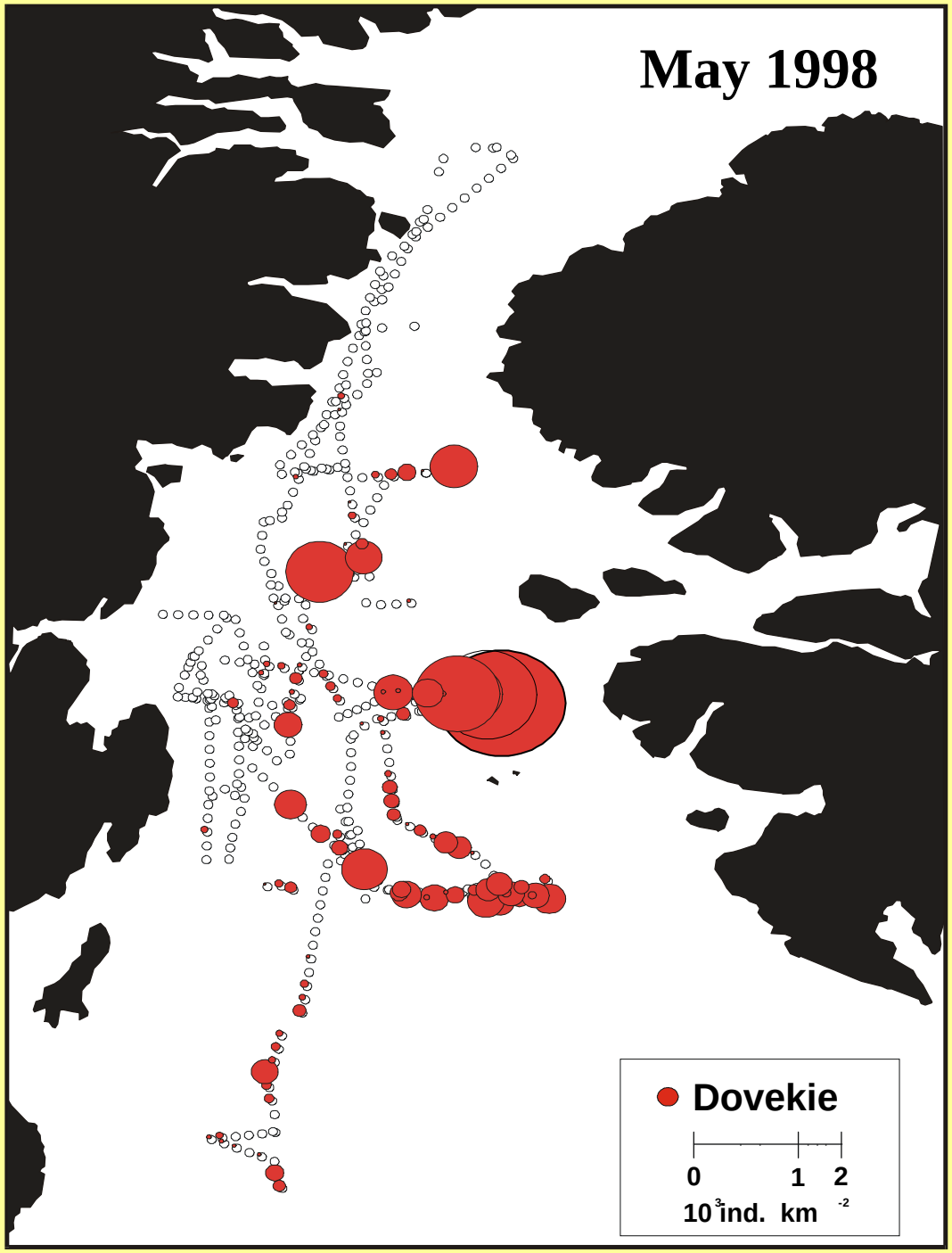
- **St. Lawrence Island Polynya, Bering Sea**
  - Latent heat polynya
  - Strong pelagic-benthic coupling
  - Important area for sea ducks and walrus




Slide courtesy of Martin Fortier

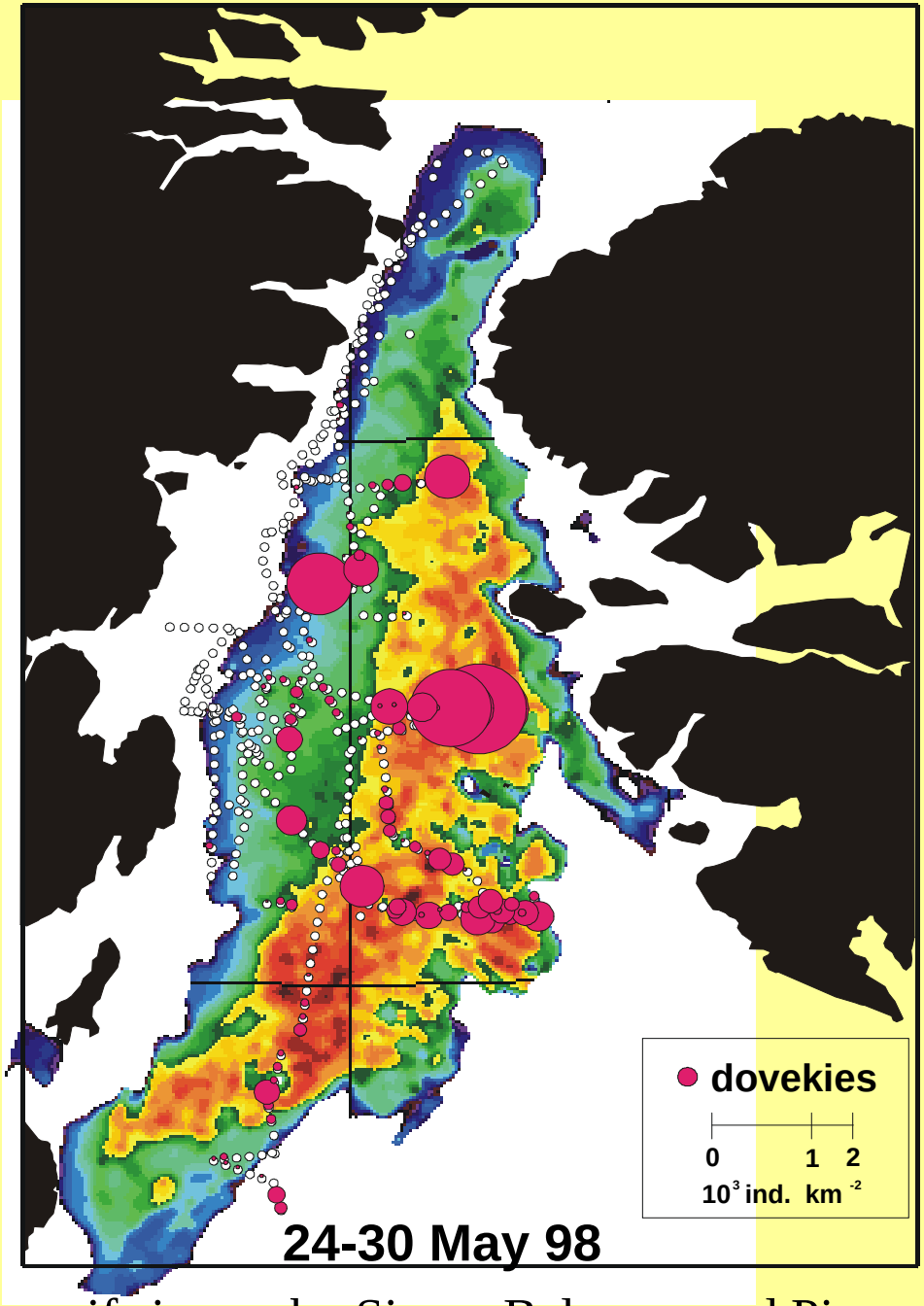
N. Karnovsky, photo

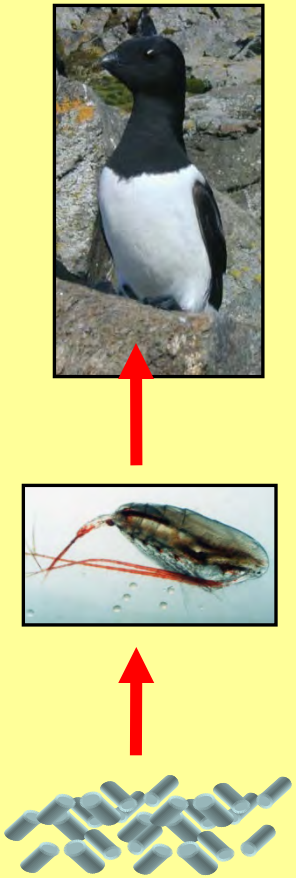
**Distribution of Dovekies on the water NOW, May 1988**




**Slide courtesy of N. Karnovsky**

95,960 – 191,920 mt C in phytoplankton to support little auks in May!



Seawifs image by Simon Belanger and Pierre LaRouche

Karnovsky, et al., 2006

# Biophysically-Forced Hotspots

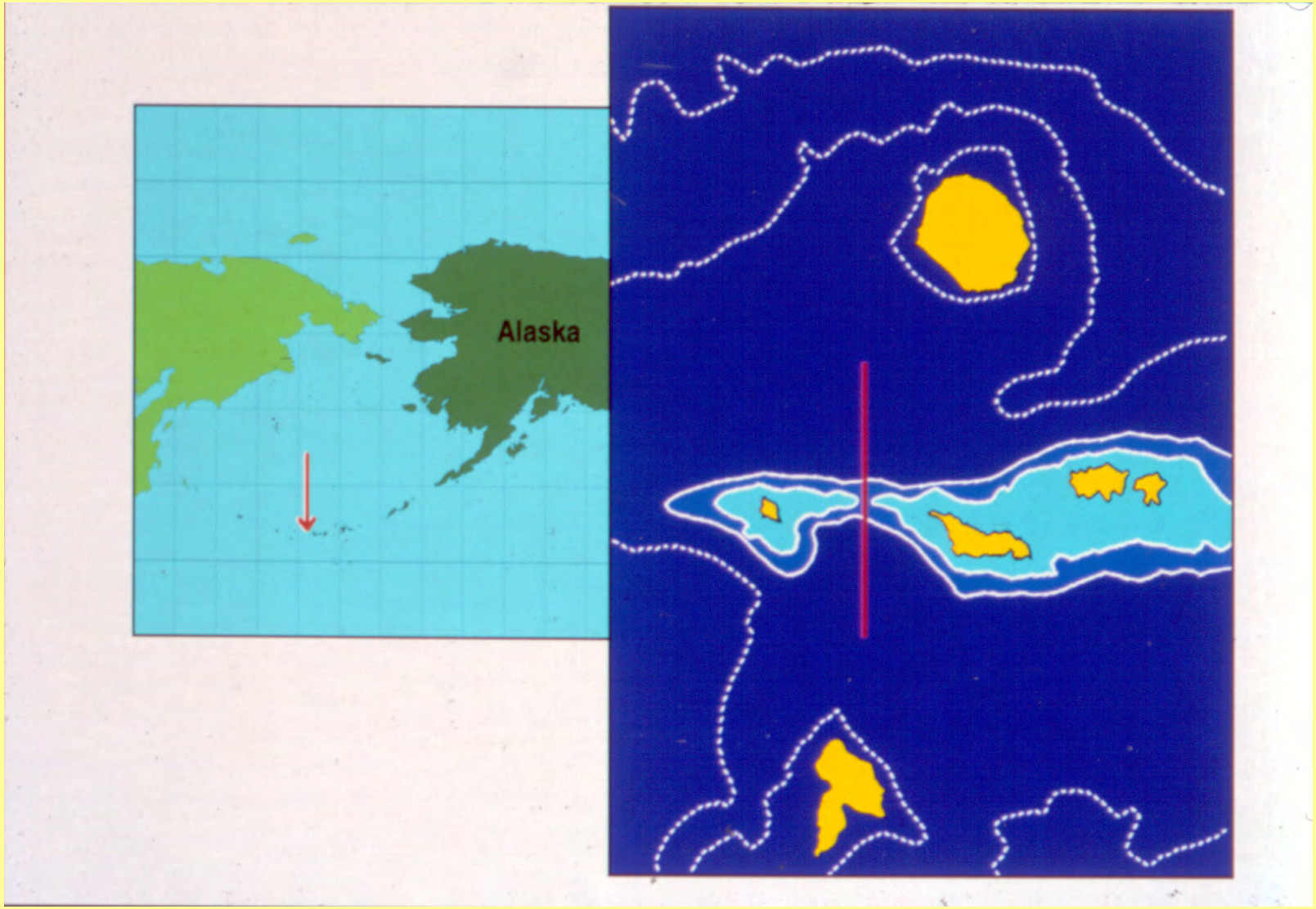
- Require source from which prey advected to be long-lasting
- Prey behavior works against physical gradient
- Many sources of gradients
    - Light
    - Density
    - Depth preferences
    - Convergence- with need to stay high
    - Divergence- with need to stay low
    - Eddies

# Examples of Physically-forced Hotspots

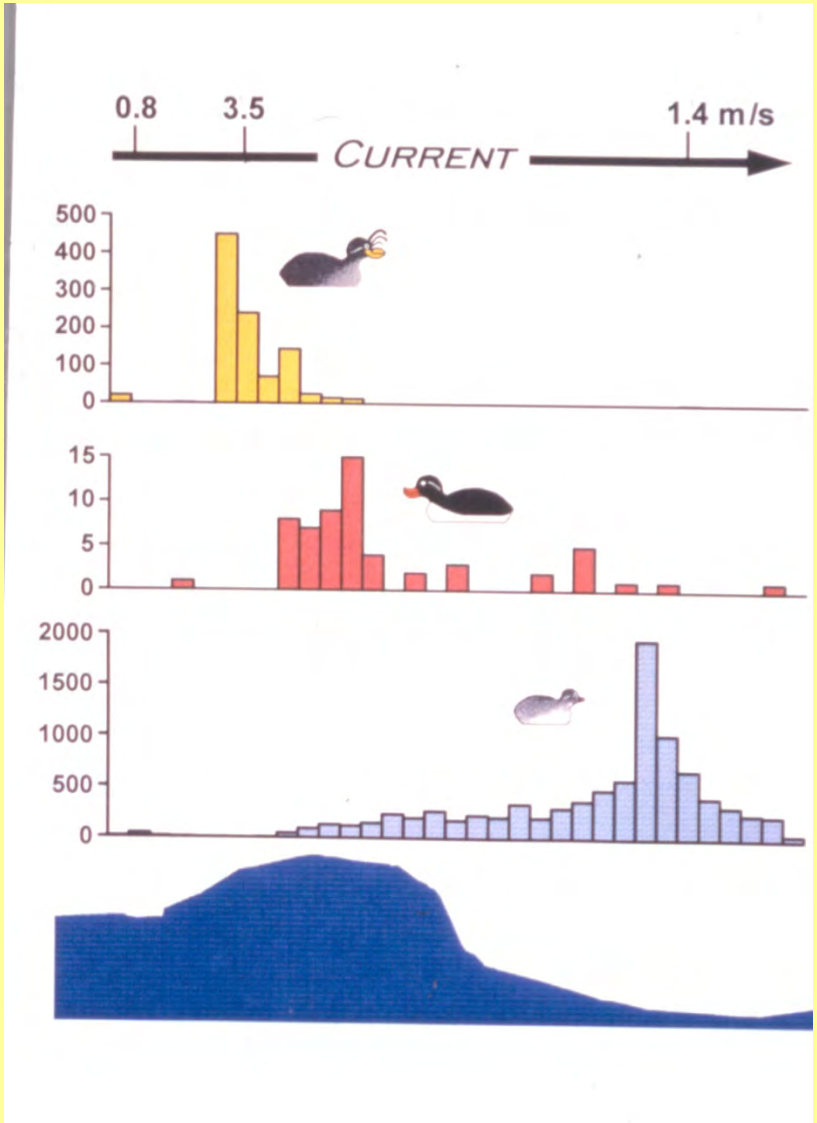
- Least Auklets at King Island- Convergence
- Least Auklets at St. Lawrence Is.- Density
- **Auklets at Delarof Is. Convergence and Divergence**

Shearwaters at Unimak Pass- Convergence, upwelling and Depth-light

# Location of Delarof Islands



# Distribution of Auklets on a single crossing of Delarof Pass



# Examples of Physically-forced Hotspots

- Least Auklets at King Island- Convergence
- Least Auklets at St. Lawrence Is.- Density
- Auklets at Delarof Is. Convergence and Divergence
- Murres at St. George Is. – Depth/Light
- **Shearwaters at Unimak Pass- Convergence, upwelling and Depth-light**

# Predator Aggregations

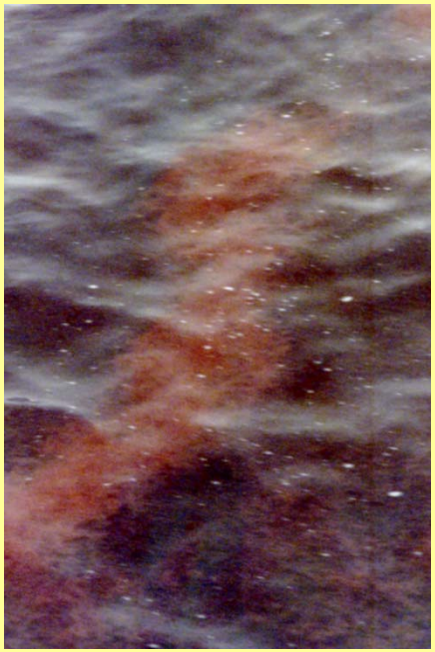

**With 2-4 birds m $^{-2}$, this flock contained 4 - 9 million shearwaters ~ 13 – 30 % of the world population**

# Prey Concentrations

**Shearwaters and Krill**
Unimak Pass, June 2002



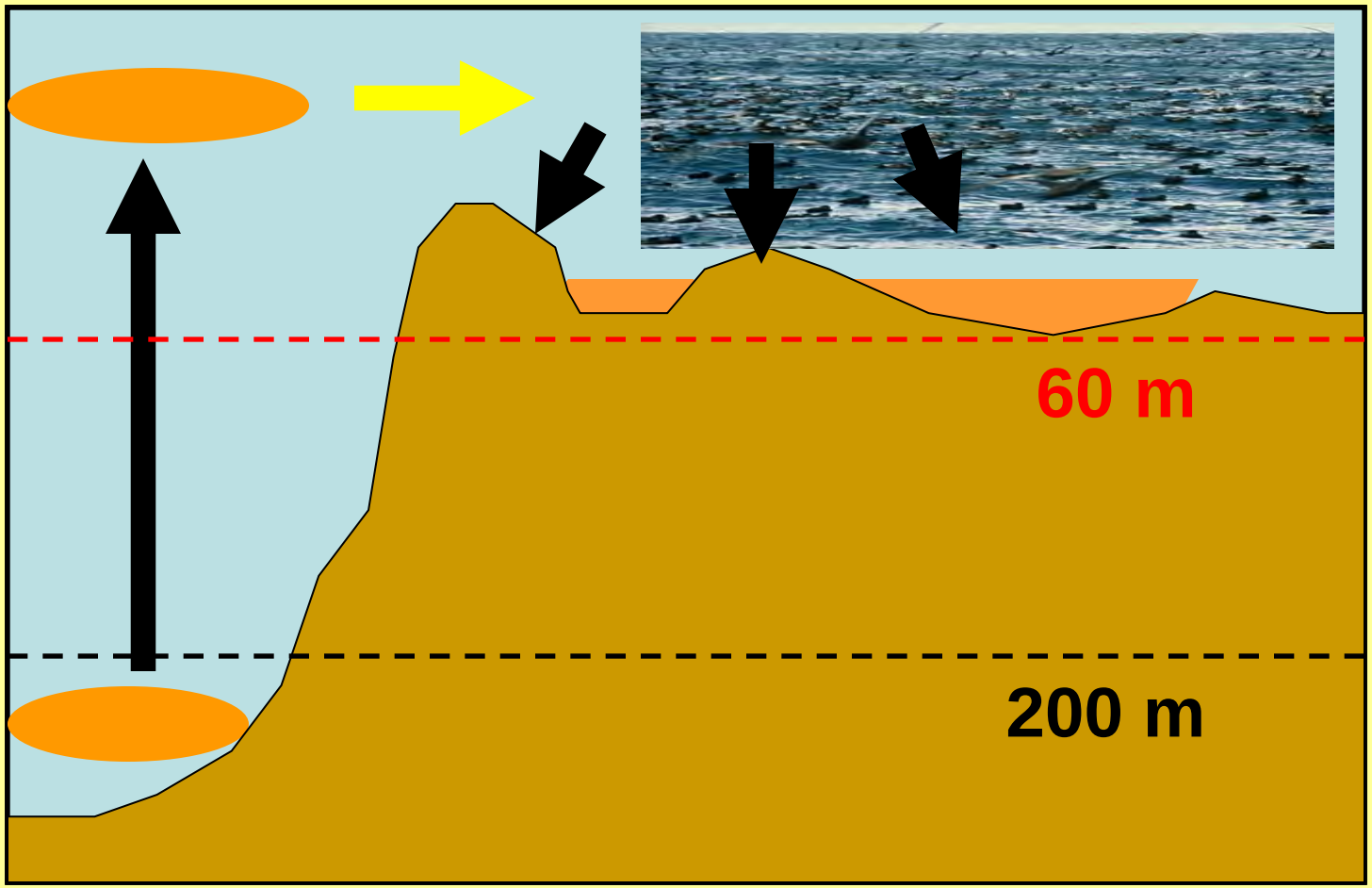

Surface view of euphausiid aggregation



Courtesy of D. Hyrenbach & J. Jahncke

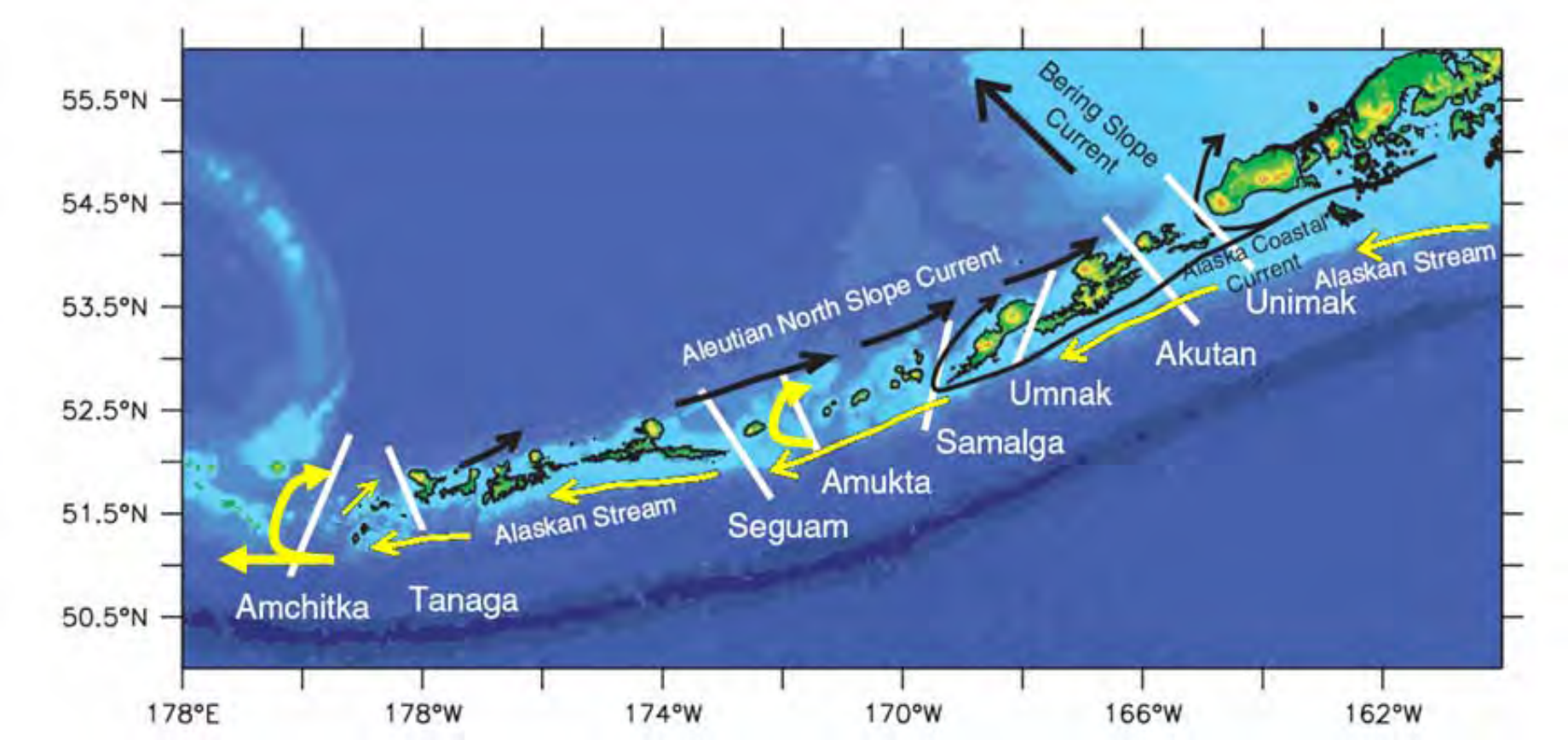
# Advection & Retention of Euphausiids

## Day-time: Shearwater Foraging




Animation courtesy of D. Hyrenbach

# What is the Source of the Euphausiids?




Modified from Ladd et al., 2005 Fish.Oceanogr.

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# Vulnerability to Climate Change

- Vulnerability of physical mechanisms-
  - Advective processes often dependent on wind patterns
- Vulnerability of prey organisms-
  - Life history traits sensitive to changes in phenology
  - Physiology sensitive to changes in temperature
  - Prey food availability sensitive to increased stratification

# Impact of Thresholds

- Timing often critical- almost no auklets nesting south of the Aleutians
- Temperature critical- timing of ice retreat affects availability of large crustacean zooplankton
- Anoxia- critical oxygen thresholds determine occupancy of a region
- pH- critical levels for araganite, also for cellular processes

# Predator Aggregations


**Shearwaters feeding with ~ 100 humpback whales.**