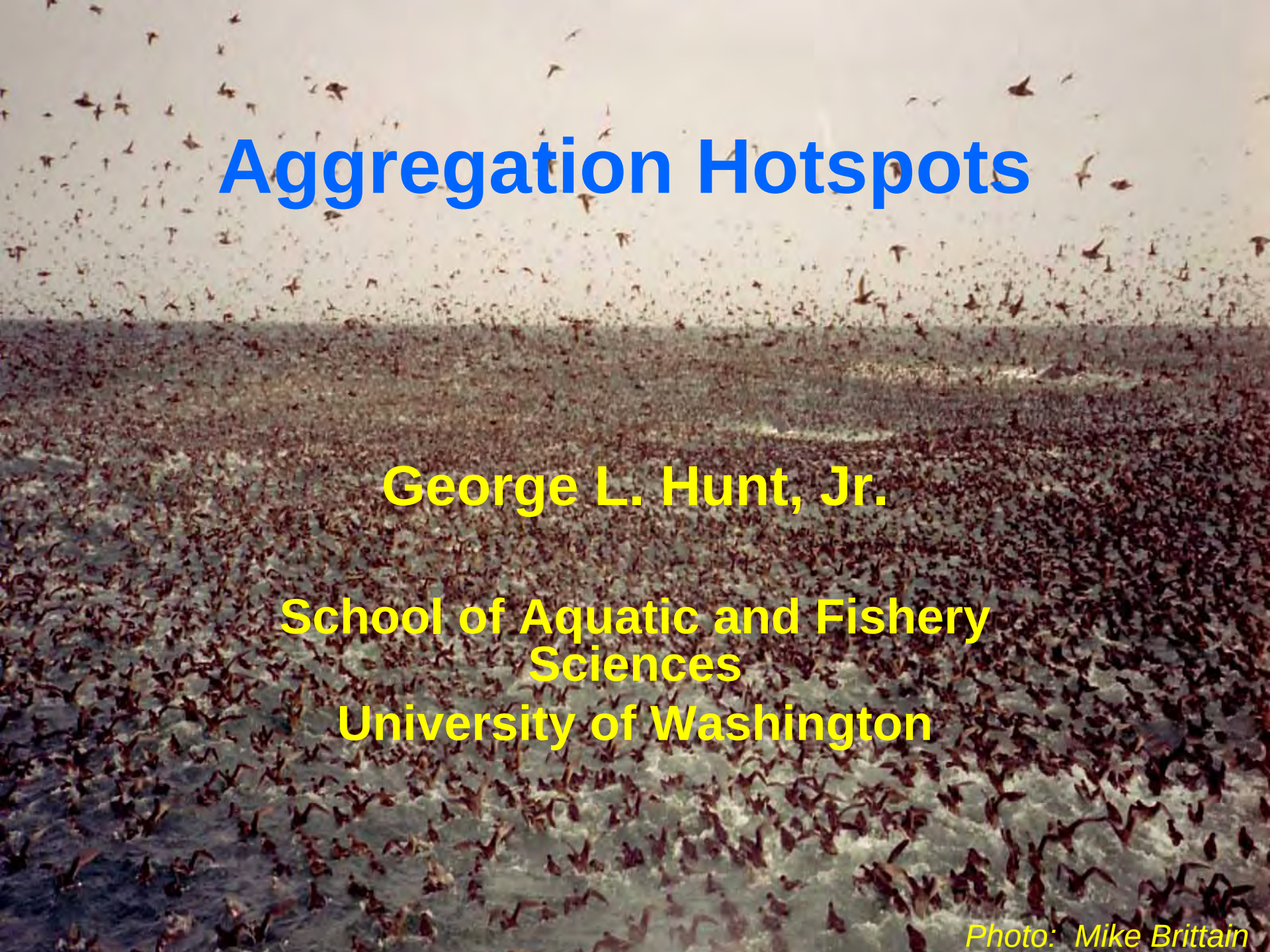
Aggregation Hotspots



George L. Hunt, Jr.

School of Aquatic and Fishery Sciences
University of Washington

Photo: Mike Brittain

Aggregation Hotspots

- Predictable in Time and Space
- Places with high rates of trophic transfer-foraging areas
  - Productivity-driven hotspots
  - Biophysically-forced retention hotspots
- Conservation significance
  - Spatial and temporal scales
  - Predictability
  - Proportion of population present

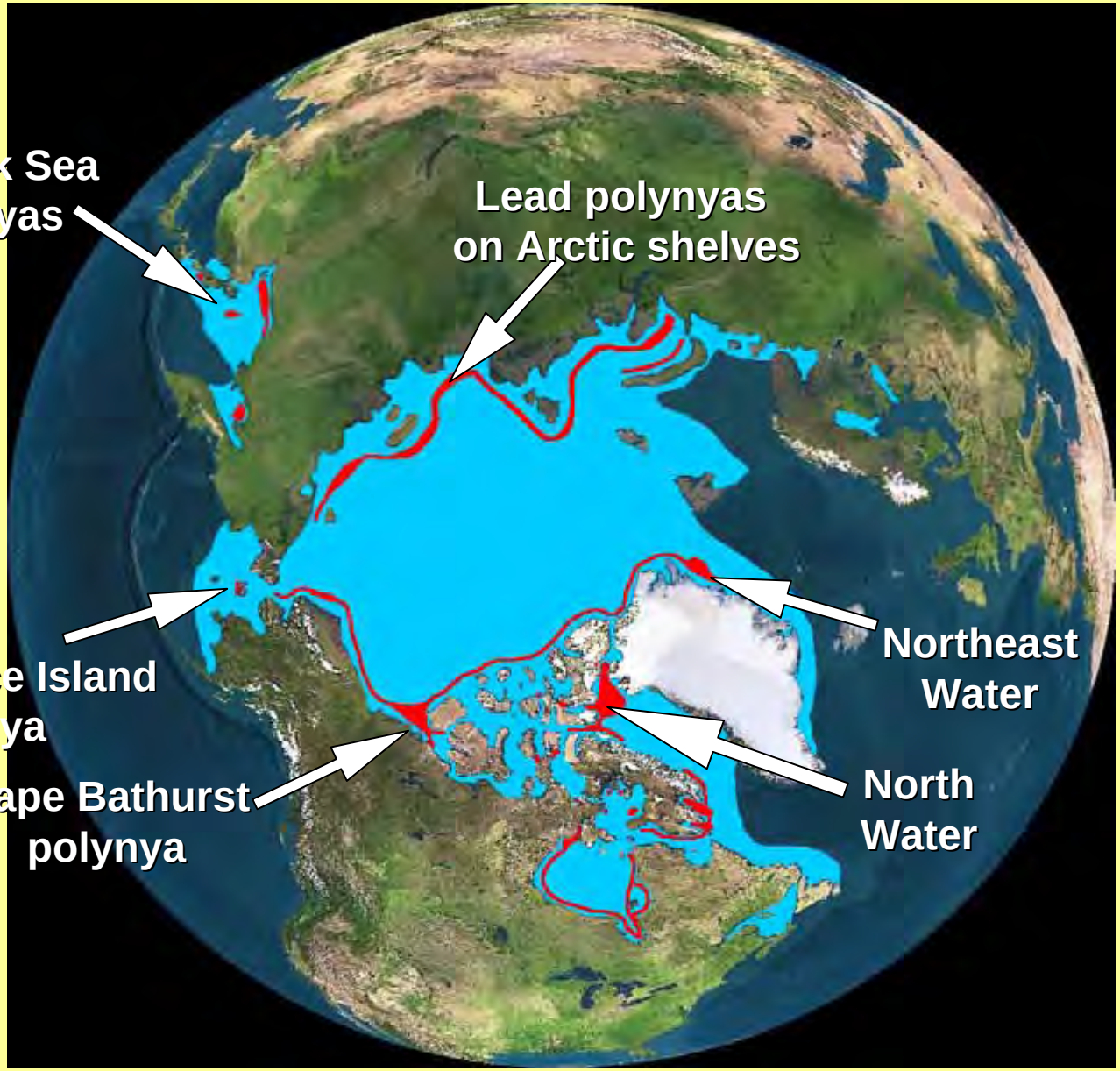
Hotspots for Trophic Transfer

- **Two major classes of mechanisms**
  - Heightened Productivity
  - Prey behavior working against physical gradients
- **Many different spatial and temporal 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
  - Scale of study depends on organism & question

Productivity-driven Hotspots

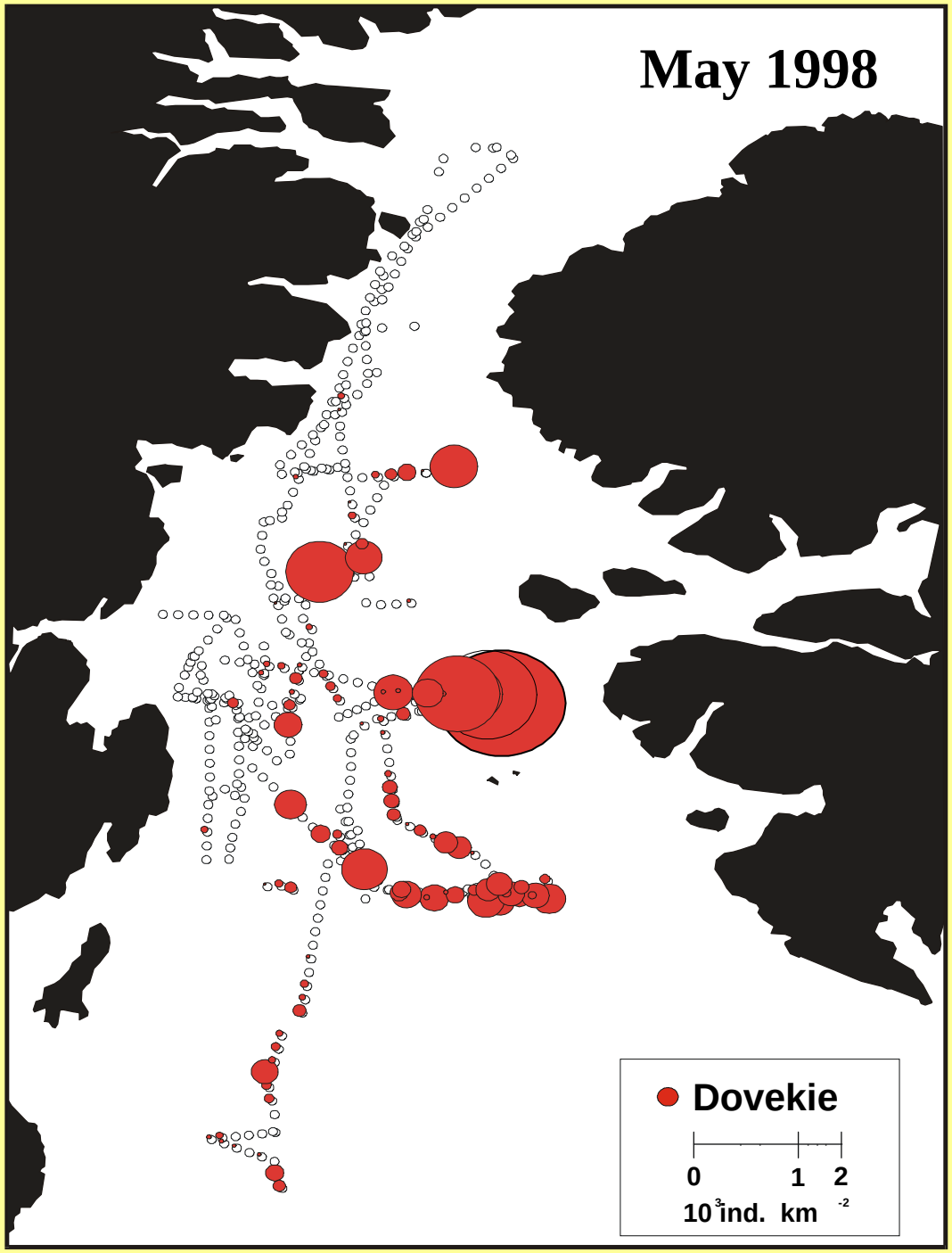
- **North Water Polynya**
  - Sensible heat polynya
  - Opens early, early bloom, large zoops
  - Supports several million dovekies

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



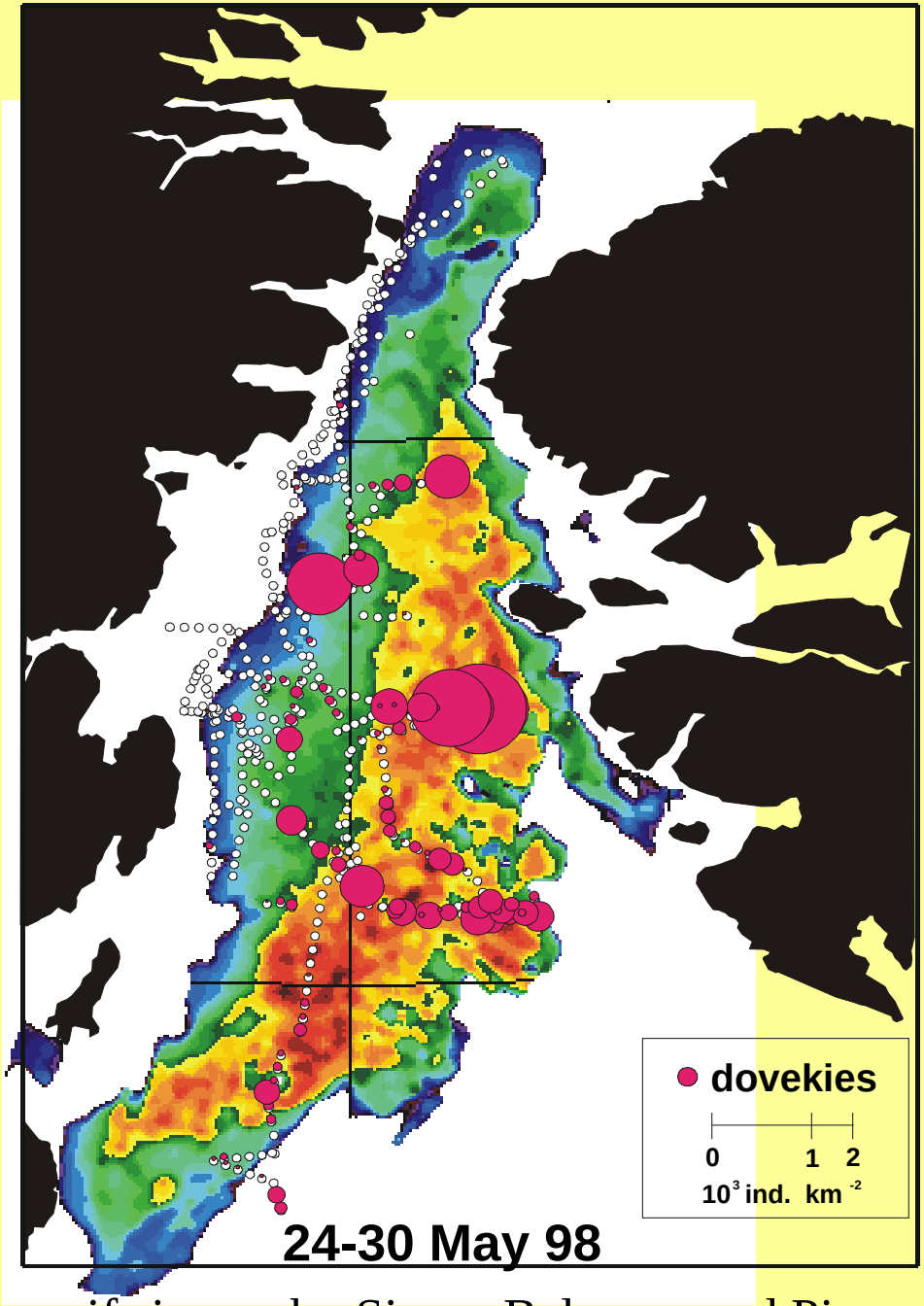
Slide courtesy of Martin Fortier

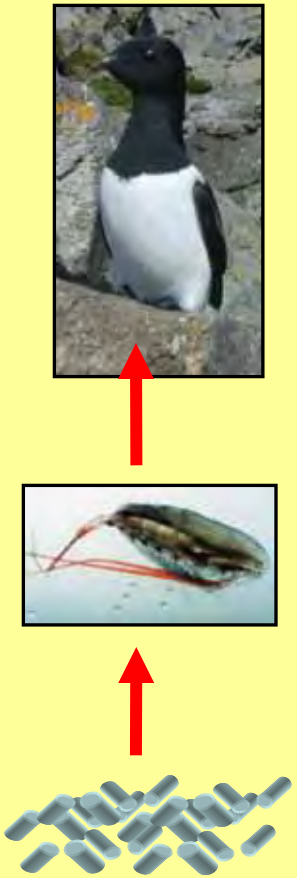
Distribution of Dovekies on the water NOW, May 1988



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

Retention-Forced Hotspots

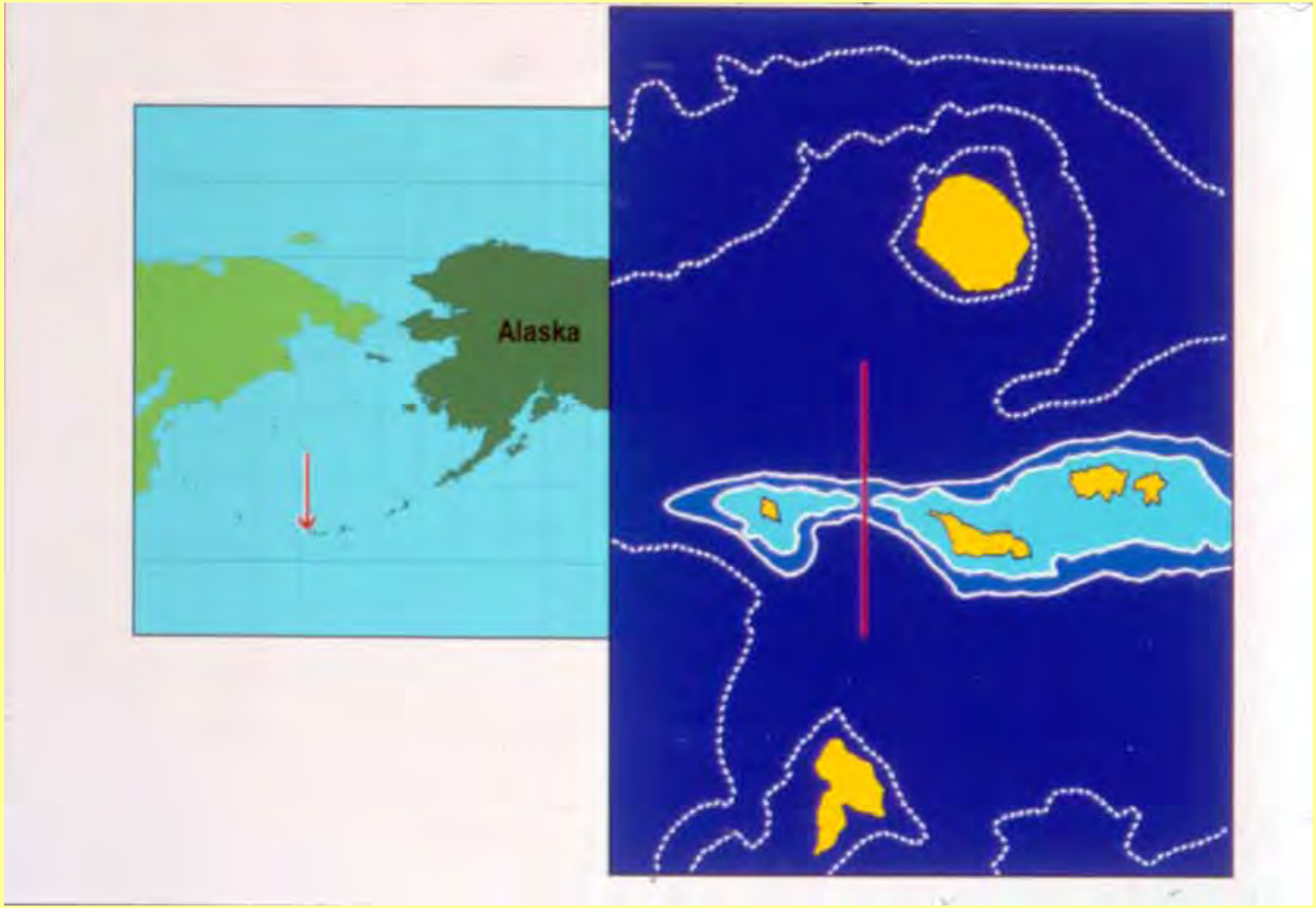
- Require source from which prey advected to be long-lasting
- Prey behavior works against physical gradient
- Many sources of gradients
  - Light
  - Density
  - Depth preferences
  - Convergence- with need to stay high
  - Divergence- with need to stay low
  - Eddies

Examples of Retention-forced Hotspots

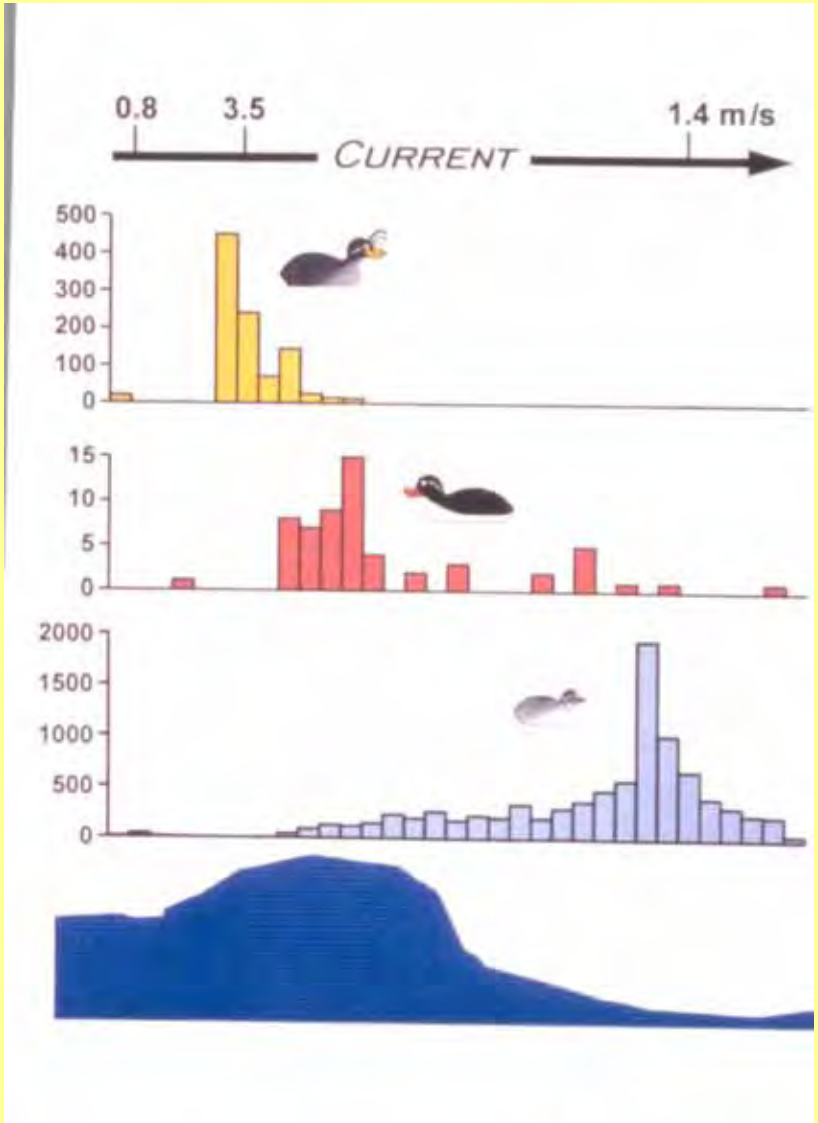
- Least Auklets at King Island- Convergence
- Least Auklets at St. Lawrence Is.- Density
- **Auklets at Delarof Is. Convergence and Divergence**

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

Location of Delarof Islands

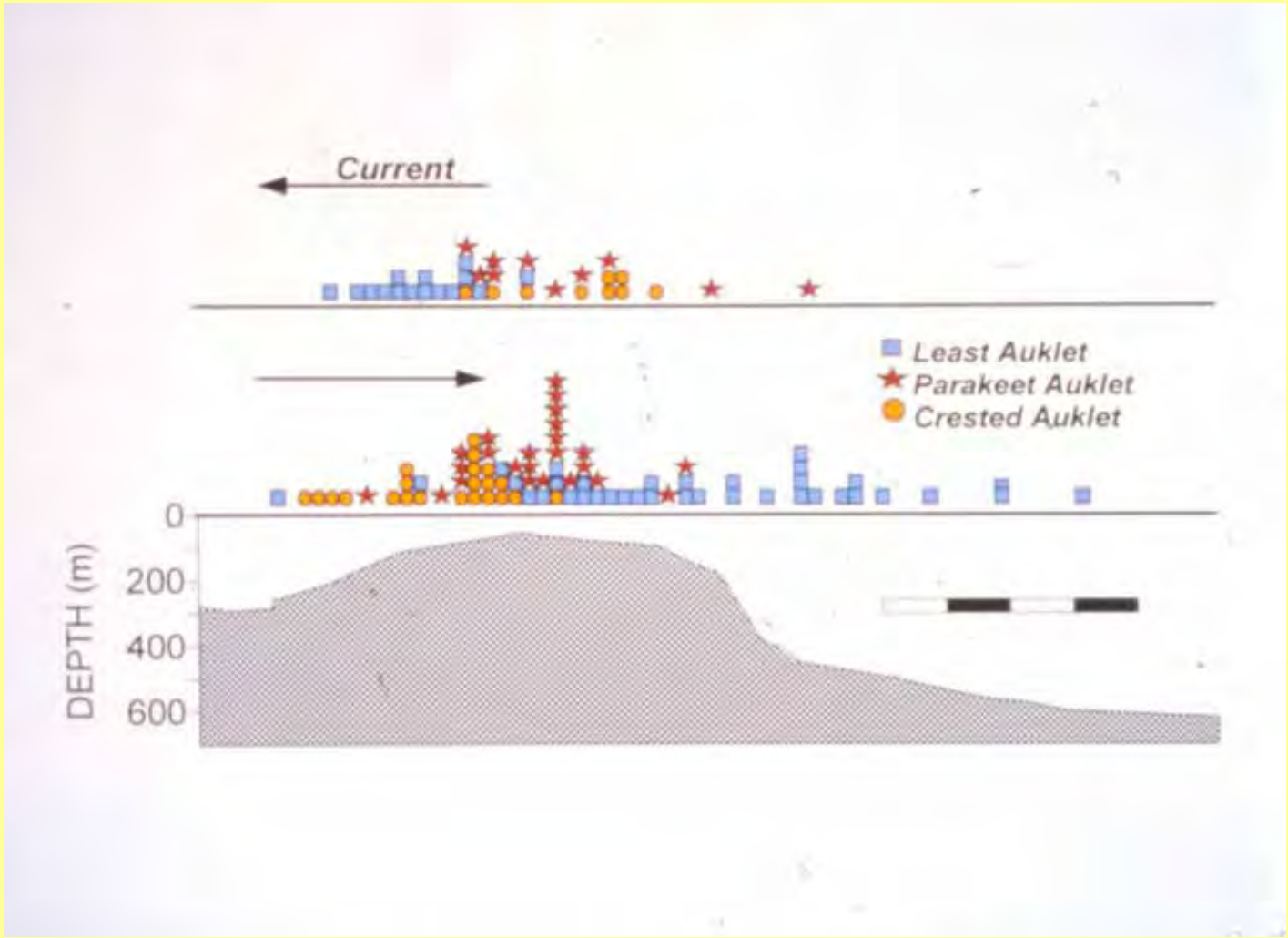


Distribution of Auklets on a single crossing of Delarof Pass



Distribution of Modes for Three Species of Auklets

Delarof Pass



Prey Distribution

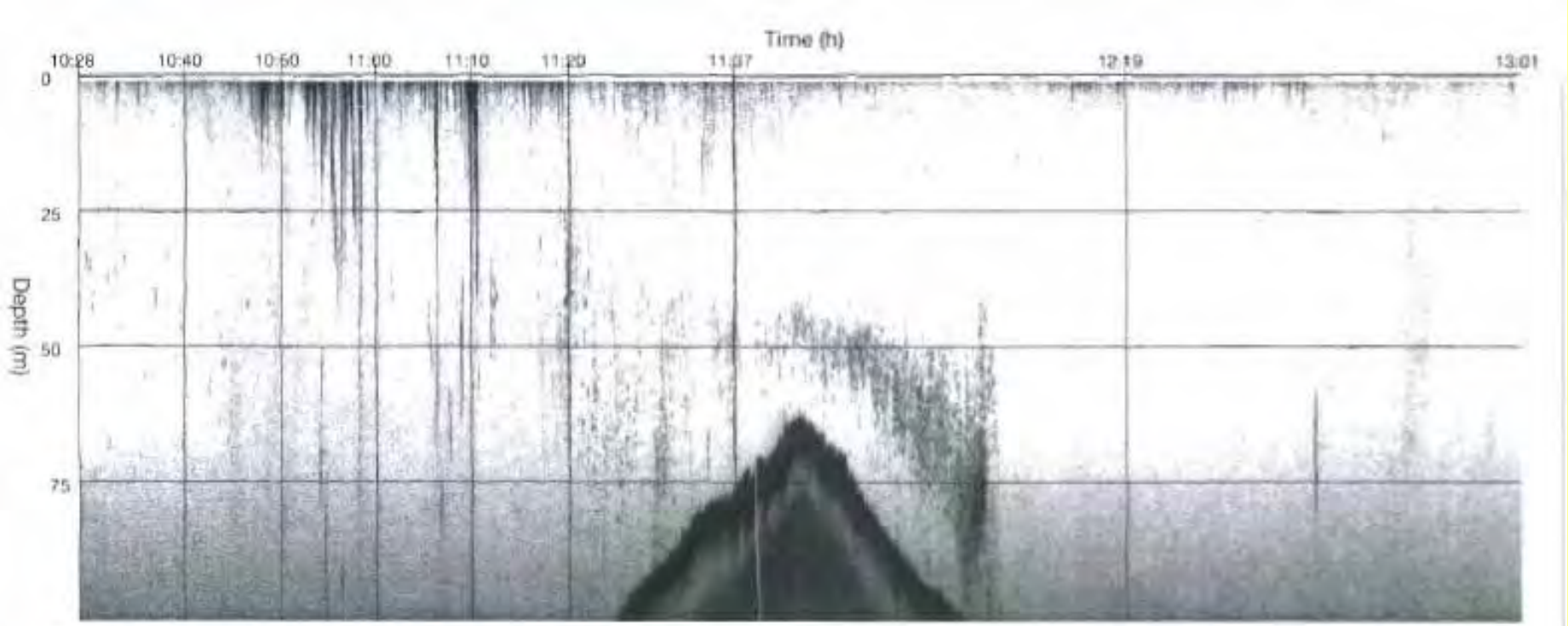


Fig. 6. Copy of an echogram from 20 July 1993 at 10:28 to 13:01 h showing biomass near the bottom on the upstream side of the sill and strong spikes of backscatter on the downstream side of the sill where the convergences occurred. Note the faint undulations in the bottom of the near-surface zone of echoes, indicating the presence of internal waves. The tide is ebbing to the south, from right to left

Correlation between Auklet numbers and Convergence rates

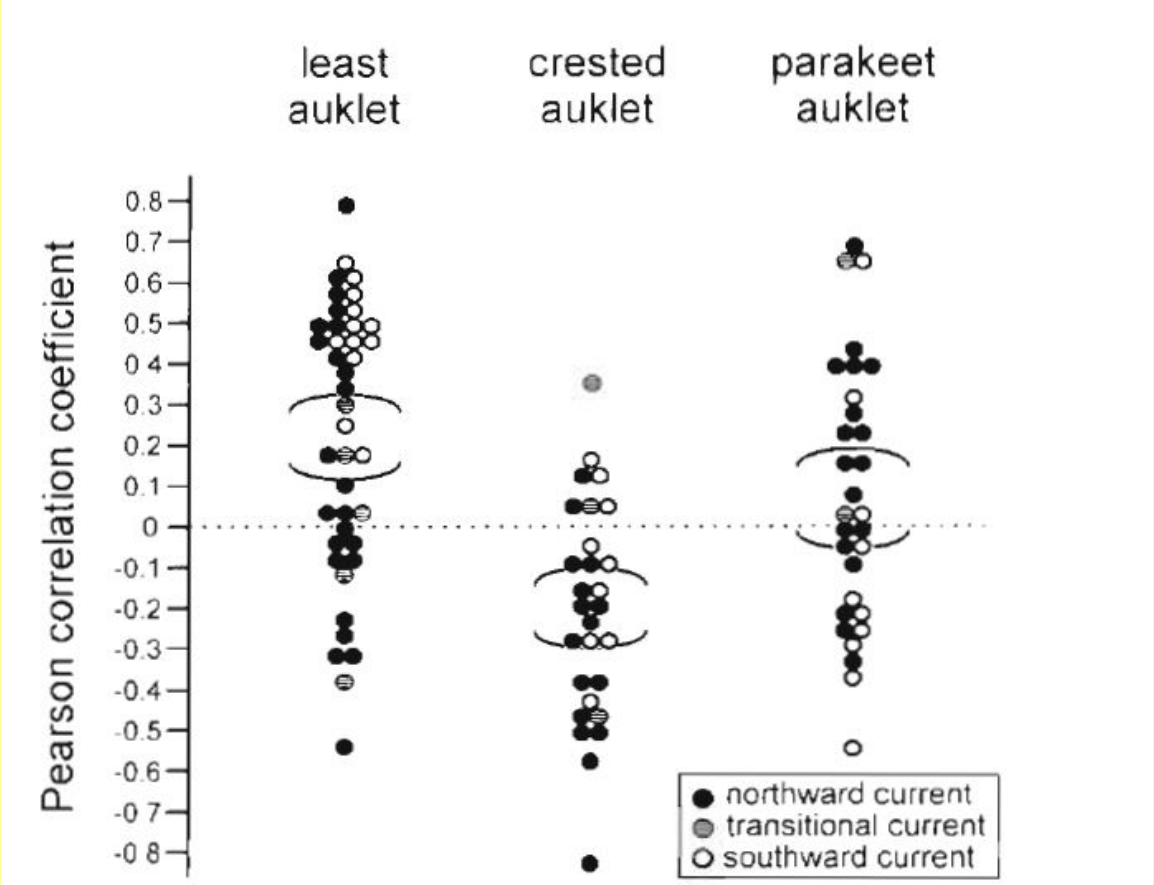


Fig. 11. Within-transect correlations between auklet numbers and the convergence rate in each bin for which ADCP data were available. Brackets indicate the 95% confidence intervals around the means

Examples of Retention-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**

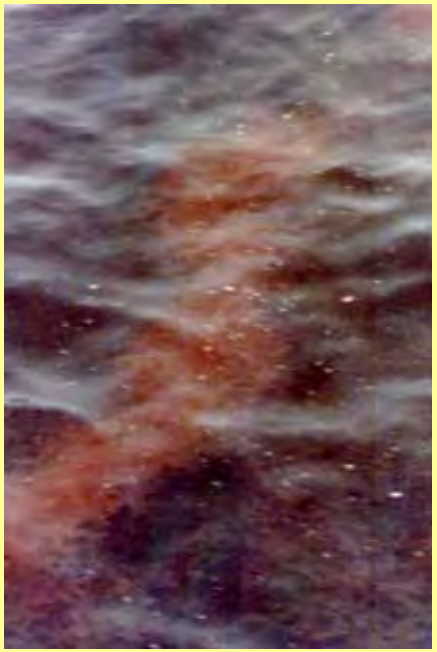
Predator Aggregations

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

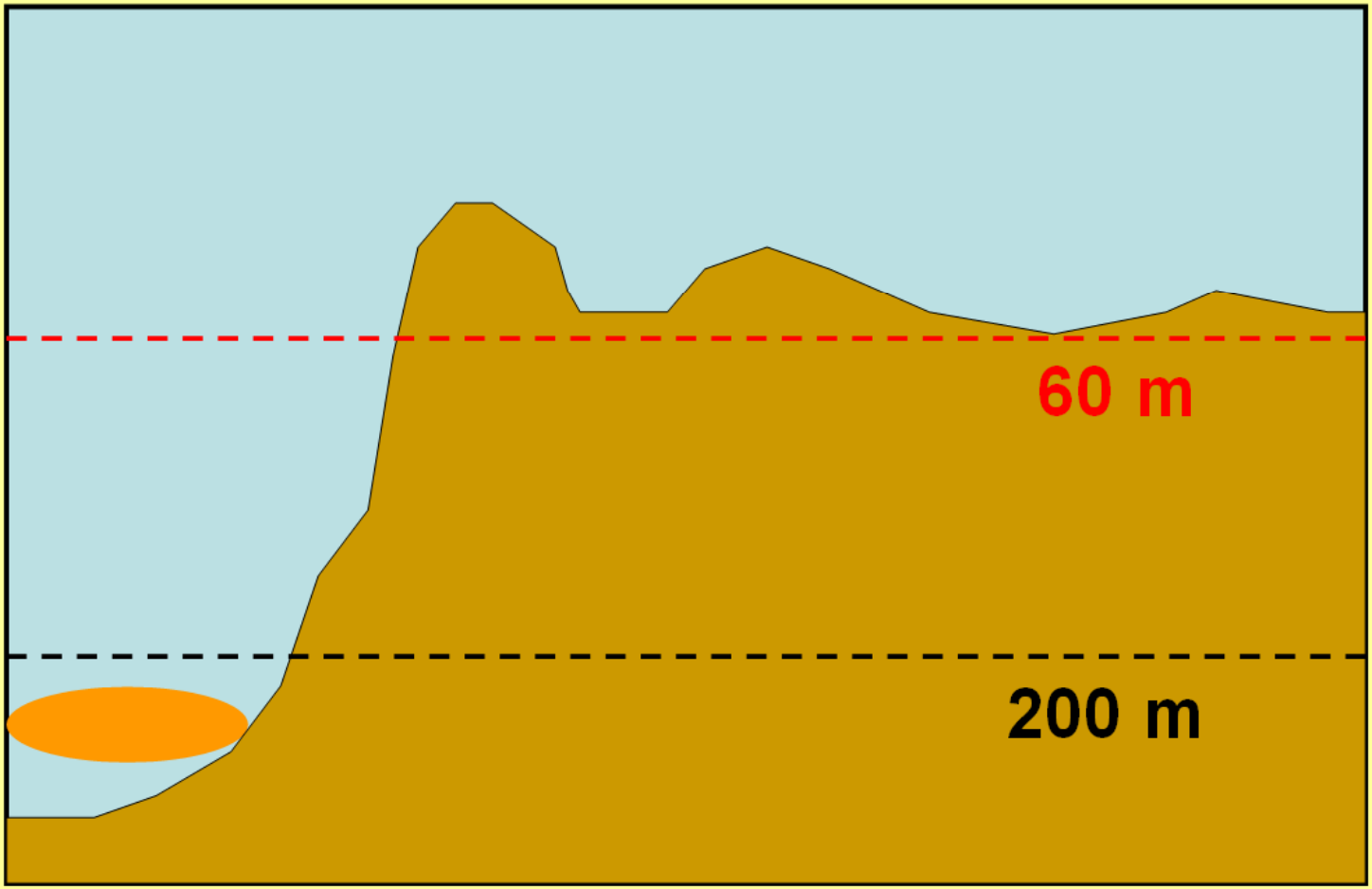
Surface view of euphausiid aggregation



Courtesy of D. Hyrenbach & J. Jahncke

Advection & Retention of Euphausiids

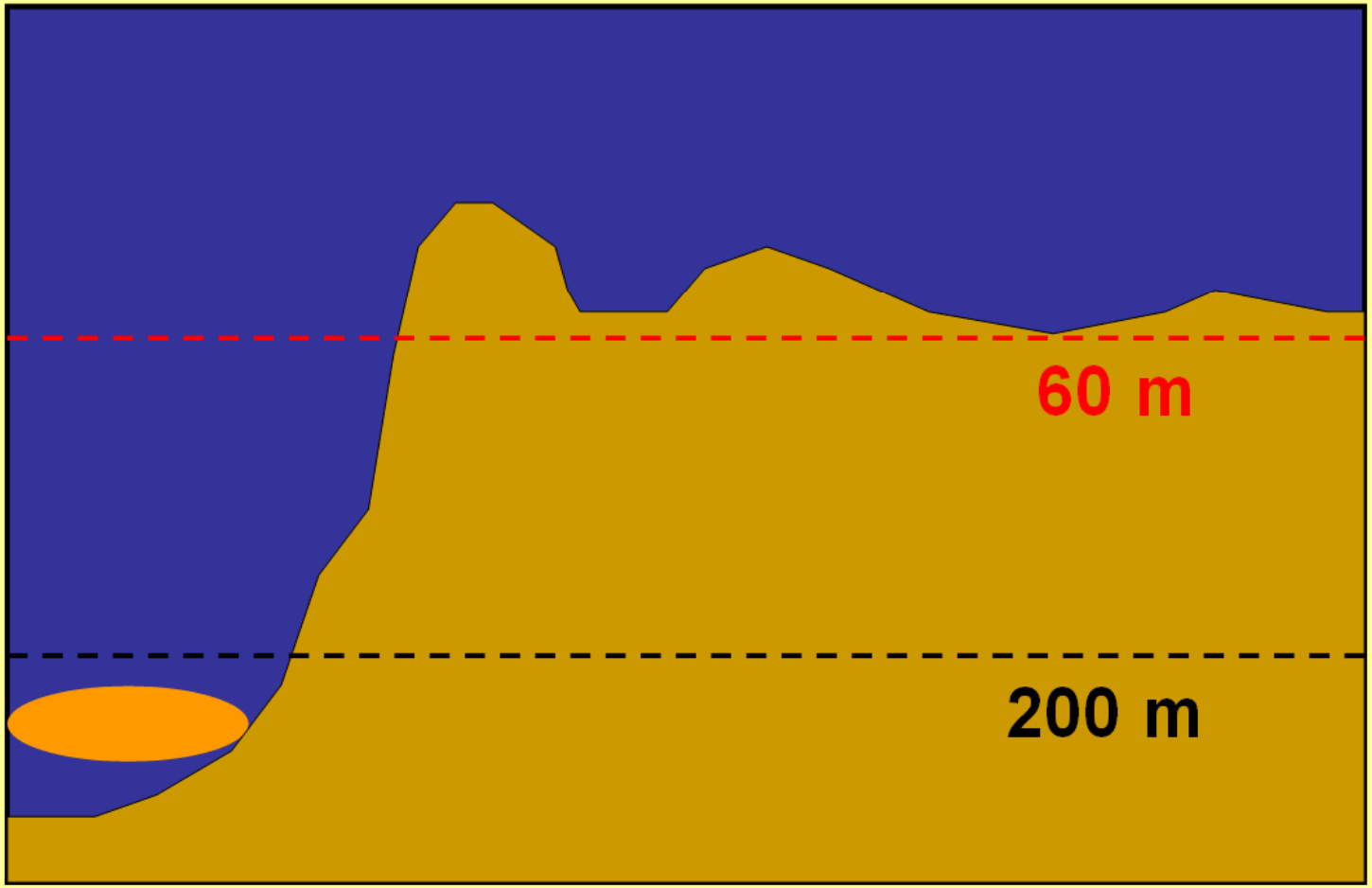
Day-time: Euphausiids at Depth



Animation courtesy of D. Hyrenbach

Advection & Retention of Euphausiids

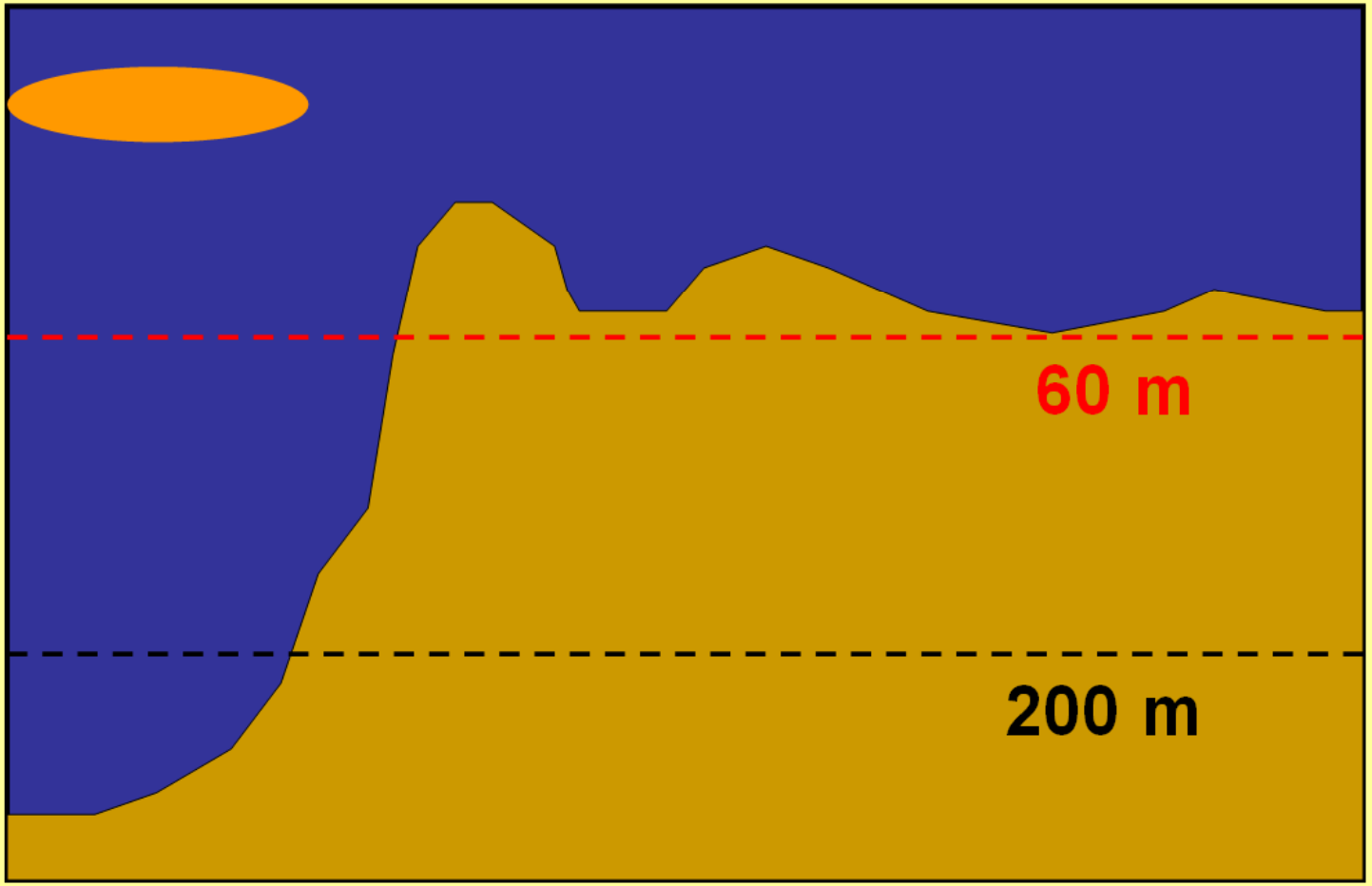
Night-time: Vertical Migration



Animation courtesy of D. Hyrenbach

Advection & Retention of Euphausiids

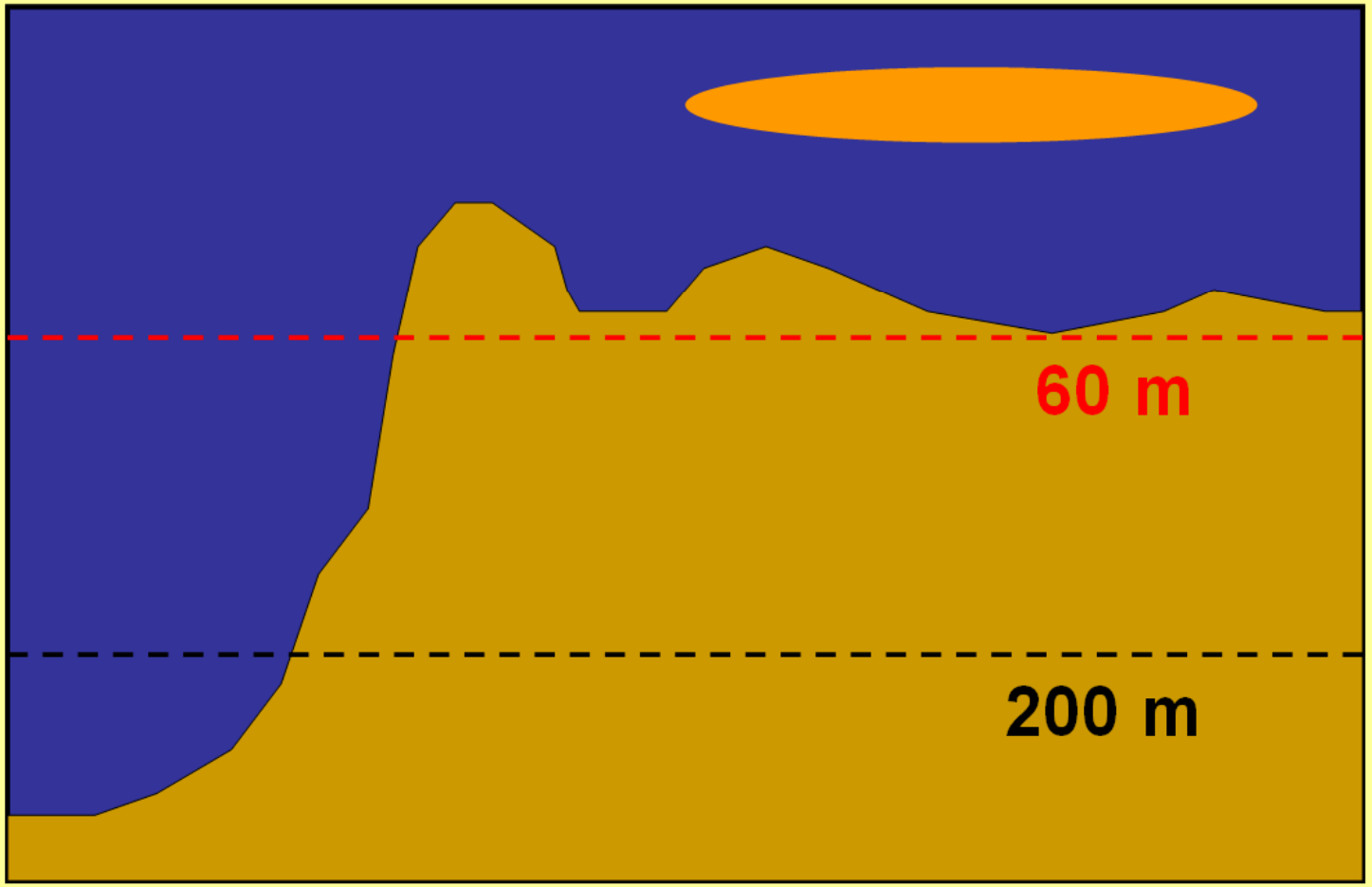
Night-time: Vertical Migration



Animation courtesy of D. Hyrenbach

Advection & Retention of Euphausiids

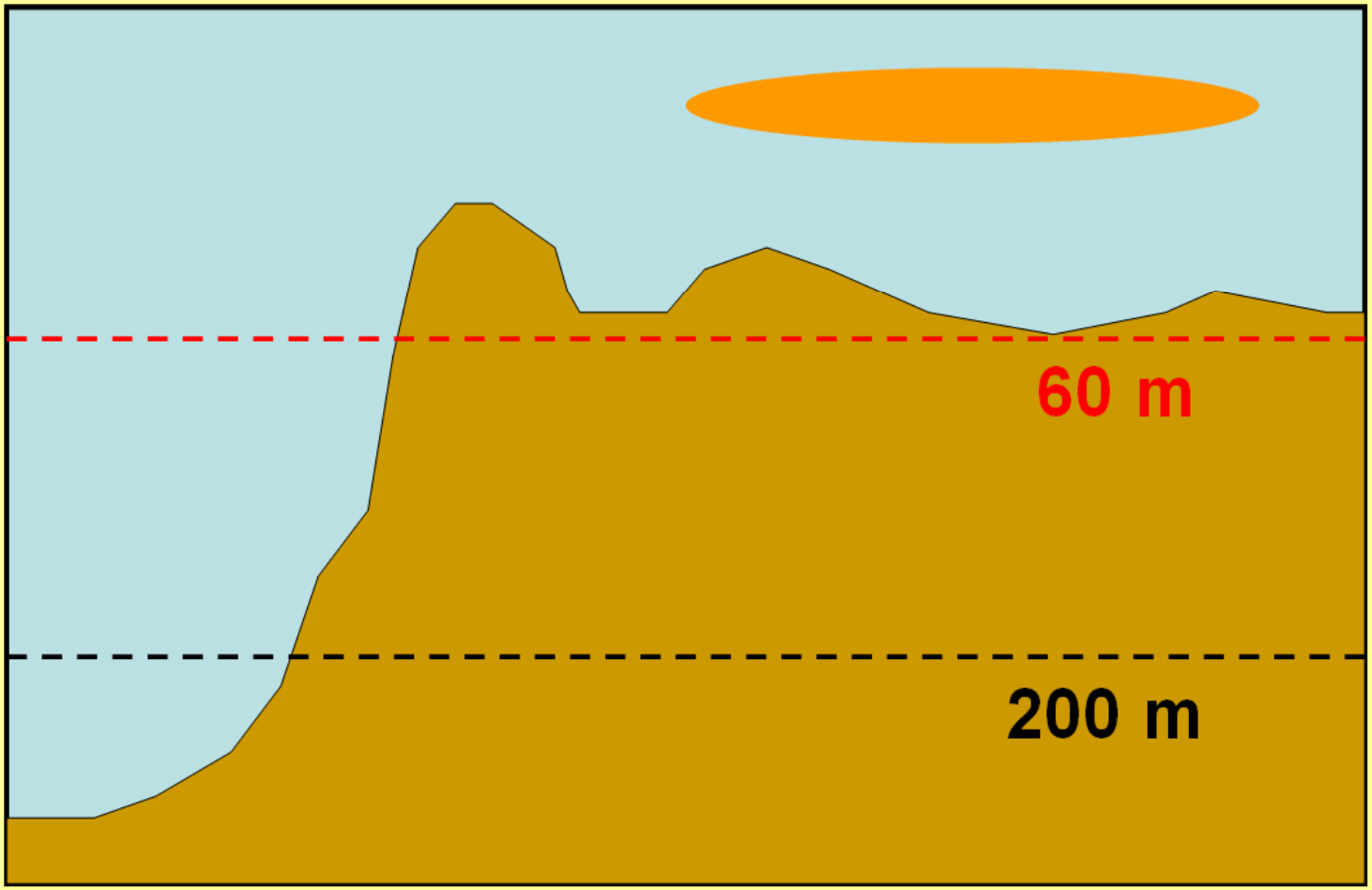
Night-time: Onshore Advection



Animation courtesy of D. Hyrenbach

Advection & Retention of Euphausiids

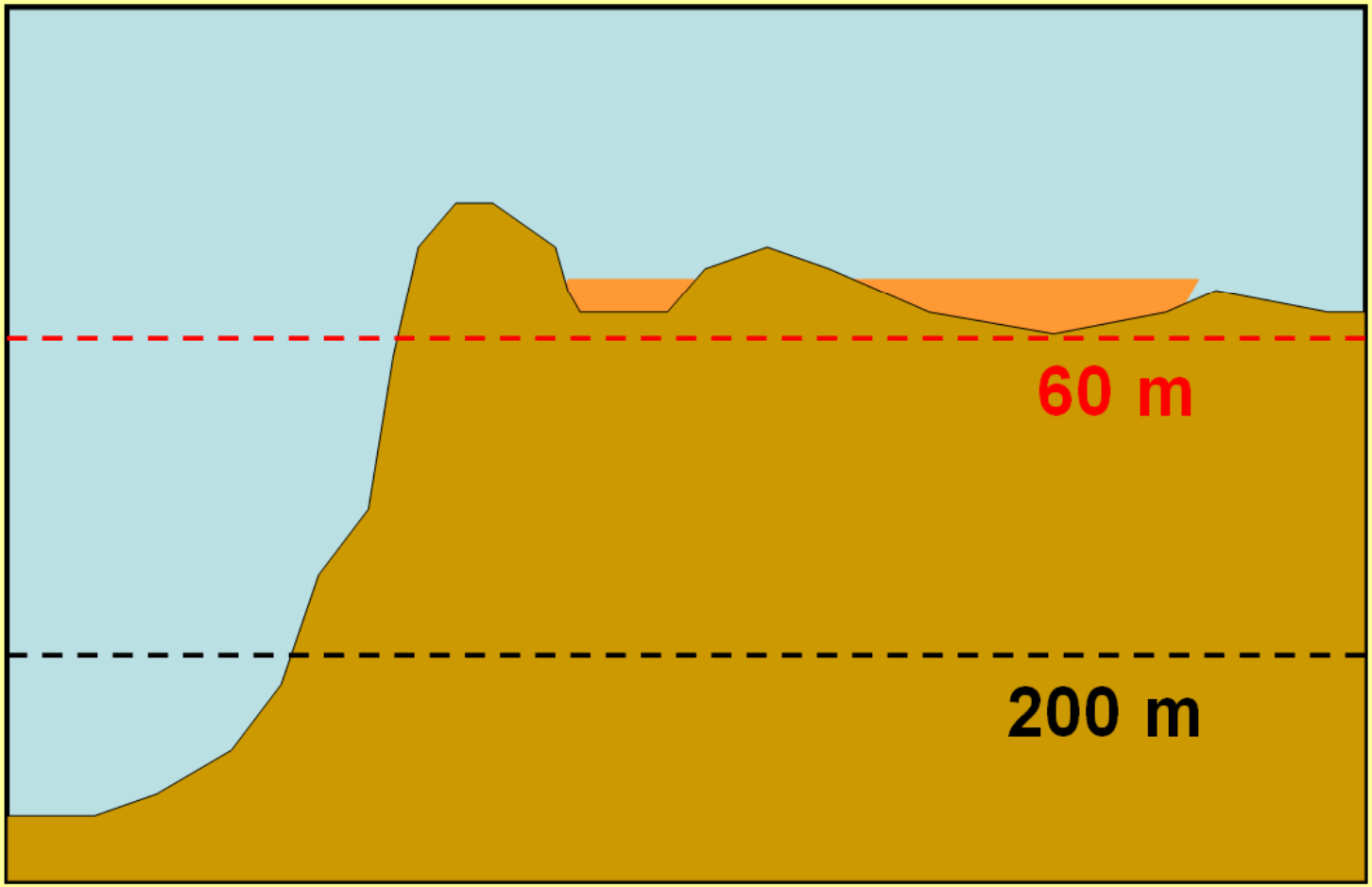
Day-time: Vertical Migration



Animation courtesy of D. Hyrenbach

Advection & Retention of Euphausiids

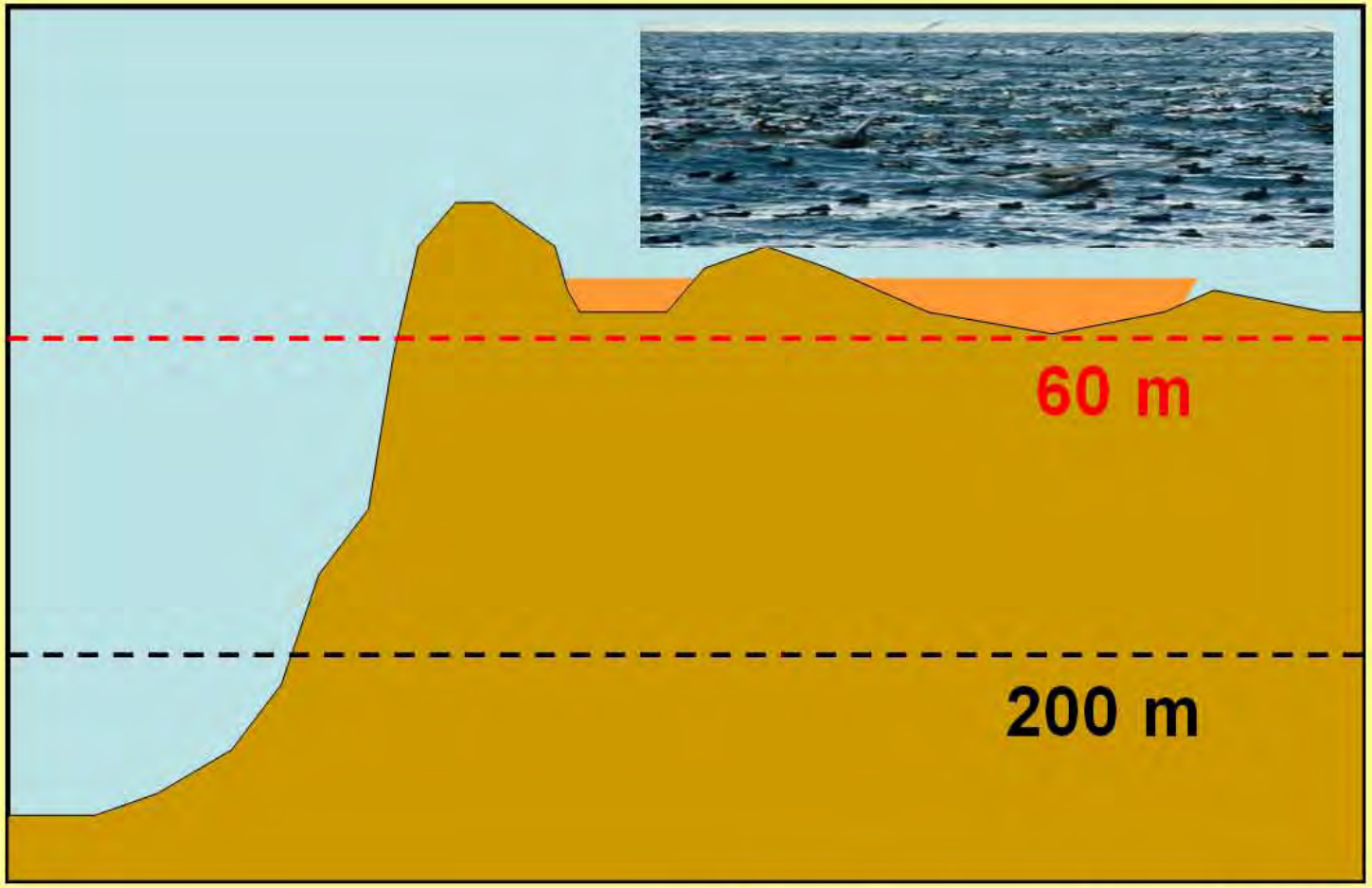
Day-time: Vertical Migration



Animation courtesy of D. Hyrenbach

Advection & Retention of Euphausiids

Day-time: Shearwater Foraging



Animation courtesy of D. Hyrenbach

Aggregation Hotspots

- **Spatial and temporal scale dependent on process causing hotspots**
  - **Habitat preferences-** Sea temperature (important for necton- fish, squid, not covered)
  - **Production related hotspots** lag production to allow development of food web
    - May be quite large in area- “warm region”
    - May be long-lasting
    - Depend on bio-physical coupling forcing bottom up processes
  - **Retention-forced prey aggregations**
    - May be very small in area- a fine-scale hotspot
    - Prey produced elsewhere
    - Prey behavior vs gradient- results in concentration
    - Locations often highly predictable

Aggregation Hotspots

- **Predictable** though not necessarily Stable in Time and Space
- Places with **high rates of trophic transfer-foraging** areas
- "**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**

Vulnerability to Climate Change

- Vulnerability of physical mechanisms-
  - Advective processes often dependent on wind patterns
  - Productivity-drivers very sensitive to change
- 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

Predator Aggregations

Shearwaters feeding with ~ 100 humpback whales.